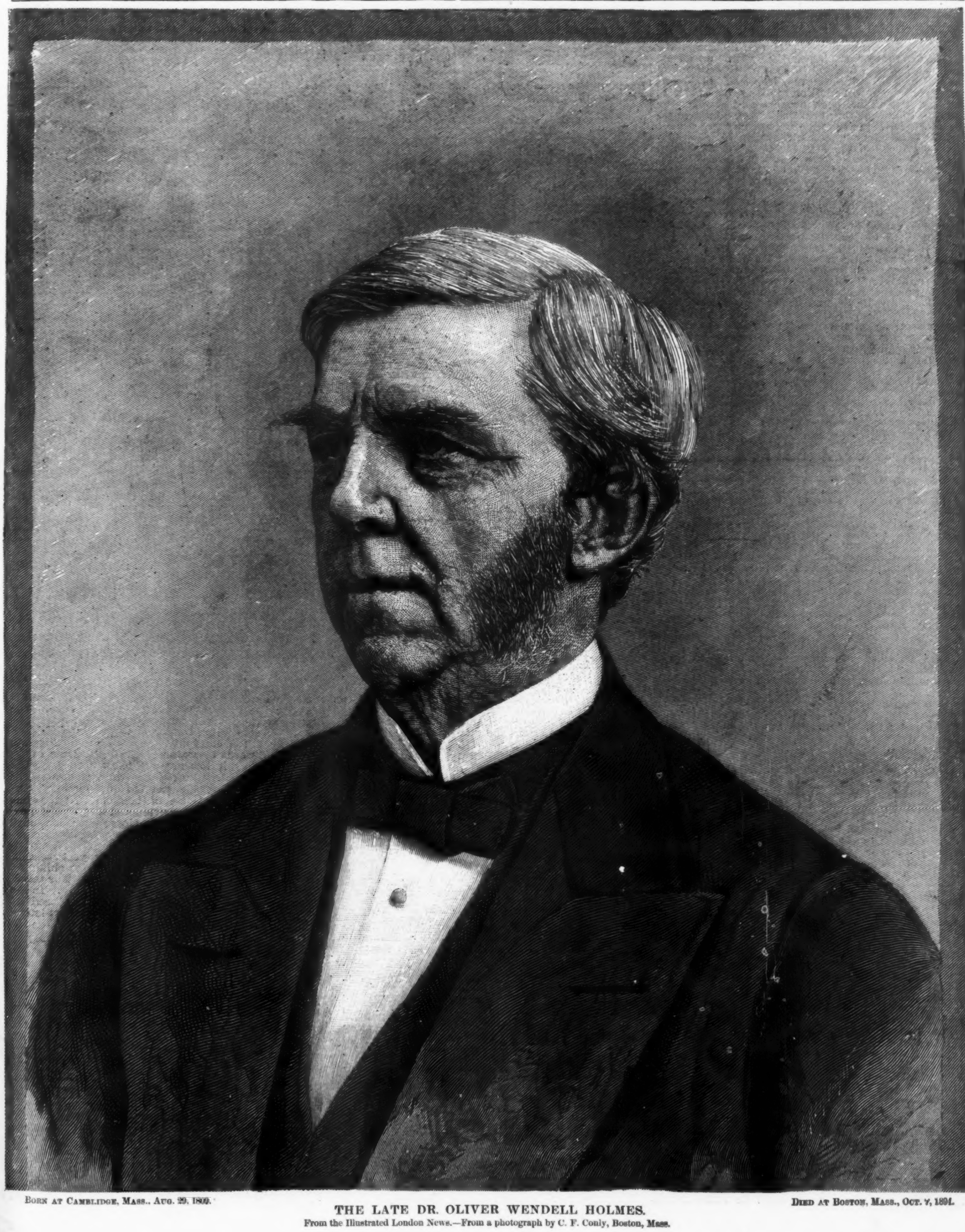
SCIENTIFIC AMERICAN SUPPLEMENT. No 990

Scientific American Supplement, Vol. XXXVIII. No. 990
Scientific American, established 1845.

NEW YORK, DECEMBER 22, 1894.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



BORN AT CAMBRIDGE, MASS., AUG. 29, 1809.

THE LATE DR. OLIVER WENDELL HOLMES.

DIED AT BOSTON, MASS., OCT. 7, 1894.

From the Illustrated London News.—From a photograph by C. F. Conly, Boston, Mass.

OLIVER WENDELL HOLMES.

THE famous poet, whose name was a household word on two continents, passed away peacefully at his Boston home on October 7 in the midst of his family.

August 29 last he celebrated his eighty-fifth birthday. At that time he said, after speaking of regaining his health: "The twelfth septennial period has always seemed to me as one of the natural boundaries of life. One who has lived to complete his eighty-fourth year has had his full share, even for an old man's allowance. Whatever is granted over that is a prodigal indulgence on the part of nature."

Oliver Wendell Holmes was born at Cambridge, Mass., August 29, 1809, of a very old New England family. He was sent to the Cambridge Primary School. Later he entered Harvard College, and was a member of the class of 1829. In college he was an excellent student and distinguished himself in literature. After his graduation he studied law for a year; he then took up the study of medicine in Boston, Edinburgh and Paris. In 1837 he began practicing in Cambridge. Two years later he was called to the chair of anatomy and physiology of Dartmouth College, where he stayed a year; he then returned to Boston and began to practice again. In 1847 he became Parkman Professor of Physiology and Anatomy in Harvard College. In addition to this honorable position he kept up an extensive practice in Boston. Yet for all this he found time to place himself in the very front rank of American literary men. In addition to his medical work he was essayist, editor, poet, novelist and popular lecturer. The doctor's medical writings gave him an enviable reputation in the scientific world.

In 1857 the Atlantic Monthly was started, and Dr. Holmes was one of the first contributors. He began publishing a series of essays which he had begun years before, entitled, "The Autocrat of the Breakfast Table." The success of the magazine was assured by these inimitable essays, which discussed with refined wit and sound philosophy the various social, moral and intellectual topics of the day. As a poet he was no less famous, and his "One-Hoss Shay" need only be cited in proof of this. "Elsie Venner" and "The Guardian Angel" are examples of some of the professor's pure works of fiction. He was an excellent orator and was early drafted to the lecture platform in the palmy days of the lyceum system. Since his death the great presses of his publishers have run day and night to supply the demand of the public for his writings. It would be difficult to find any home in America that makes any pretensions to culture where Dr. Holmes' writings are not either owned or read. Hardly any American man of letters was better known in England, and thousands mourn his loss.

MODERN ABUSES OF THE EYE.

By G. W. McFATRICH, M.D., Chicago, Ill.

THE eye is the organ of sight. It is situated in a large bony cavity (the orbital cavity) in the upper part of the face. Surrounded as it is by bony prominences, and having at its disposal two movable lids, each guarded along its edge, in the healthy state, by lashes, it can readily be seen that it is as secure from injury as it possibly can be. There it can boldly stand and investigate objects at the pleasure of its owner.

Rays of light emanating from an object fall upon the anterior surface of the eye (cornea) and pass through its refracting media, whose duty it is to so direct them that they will meet at a common point upon the retina; which, in the normal eye, is strictly attended to.

The retina, which is practically the expanded termination of the optic nerve, is a delicate membrane lining the interior of the back part of the eye, and upon which, if true to its trust, a correct impression of the object is made, which in turn is transmitted through the optic nerve to the brain, and the mind becomes sensible of the object to which attention is directed.

Not unlike other useful members, the eyes are often objects of serious abuse. In some parts of Europe parents not unfrequently have applied hot irons to the eyes of their children, in order to make of them pitiable objects of charity; and send them out to beg, that philanthropic persons may drop a few pennies into their cups. Such are the atrocious crimes of some of the lower classes, but to what state of depravity has a man descended who, either from shiftlessness or cowardice, performs, or causes to be performed, like mutilation upon his own body, that the arduous and dangerous tasks of military duty may be escaped.

But let us, for a few brief moments, pause and consider the abuses to which this delicate and intricate organ is constantly being subjected in this civilized land. How discouraging it is to note that as civilization and education advance, abnormalities of the eye relatively increase.

To corroborate this startling statement, one has but to consult statistics. It is often and quite plausibly argued that as civilization and education advance, knowledge in diseases of the eye increases, and consequently many irregularities of sight, which in former times were unheeded, or from lack of knowledge were either neglected or maltreated, are now diagnosed or corrected; and while this argument is a strong one, yet it grieves me much to say, it does not modify or detract from the statement that the high pressure and competitive examination of our present educational system are responsible for many cases of abnormal vision, and that the advancement of the same is producing a relative increase of the troubles.

Cinders under the lids, instead of being promptly removed, are too often allowed to remain where they have lodged until a severe inflammation is excited, and the patient yielding to an almost irresistible desire to rub the eye, more deeply embeds the cinder, and augments the inflammation, until finally a severe case of conjunctivitis, which often results seriously, is established. It is the duty of every physician to instruct his patrons to either remove these foreign bodies themselves, or to have them removed by their physician. Patients can very frequently remove cinders by drawing the upper lid down over the lower, and making gentle pressure while the lid is allowed to slide back into place. Care must be taken not to handle the eye too roughly, and the patient or his friends must not work too long. If any difficulty is encountered, he should go at once to the physician, as those who are not expert often do the eye more harm in removing the foreign body than it would itself do if allowed to remain. At any rate, a foreign body under the lid should be promptly and judiciously removed.

Ulcers of the cornea are very frequently allowed to progress to an alarming extent before any attention whatever is given them. Since micro-organisms may enter the tissues of the cornea through a slight abrasion and produce an angry, dangerous ulcer in an incredibly short time, and produce irreparable damage, it behooves us to be on the lookout for troubles of this nature. Usually the symptoms of ulcer of the cornea are so prominent—extreme pain, intolerance of light, hazy appearance of the cornea, etc.—that very little difficulty is encountered in arriving at a diagnosis, but it often transpires that no other symptom than a sensation of itching precedes an ulcer of the cornea; and as I am writing this I am painfully reminded of a young man who came to me one morning with an ulcer which had already involved one half of the cornea. The iris had prolapsed and was drawn into the wound, and before the terrible process could be checked fully three-fourths of the cornea had been destroyed. At the present time a large, opaque spot, fully two-thirds the size of the cornea, remains, and I do not think the eye will ever be of much service to him, unless an artificial pupil be made behind some portion of the cornea which is still transparent.

This man stated that a sensation of itching was present about twenty-four hours previous to his coming to me. This was in the morning, and by night a slight stinging pain was present. The next morning he arose with a well developed violent and progressive ulcer of the cornea.

The iris is a thin, delicate, muscular curtain, which is suspended in the eye between the cornea and the lens, and is that structure which gives to the eyes color—brown, blue, hazel, etc. It is perforated near its center by a small, round aperture, the pupil. This aperture is made smaller or larger, according to the demands of the retina for more or less light. It is imperative that the free movement of this intricate muscular curtain should not be interfered with. Very often this little structure becomes inflamed (iritis), and in consequence of which a plastic inflammatory deposit is thrown out and the iris becomes adherent to the capsule of the lens, which is situated immediately behind it. A plastic material is also deposited between the fibers of the iris itself, when it becomes partially, if not totally, immovable; and not infrequently forty-eight hours are all that is required to render it incurably adherent, when the vision will be permanently impaired; where, if a solution of atropine (gr. ij to ℥ j) had been instilled into the eye at the outset, this complication would have been avoided.

Iritis usually commences with pain in the eye itself and in the immediate vicinity, of a neuralgic or rheumatic character; intolerance of light; and soon the white portion of the eye becomes red, with numerous delicate blood vessels running up almost to the cornea, where they apparently suddenly stop. At this point they penetrate the eye ball and nourish the iris. Many cases, however, become fully developed with no other symptom than a slight rheumatic pain as the eye is rotated from side to side.

Another of the many abuses to which the eye is subjected is over-taxation. Some persons use their eyes all day and then set up for two, three or four hours at night and use them by artificial light. It is needless to say that this practice is harmful. The eyes soon begin to smart, tears are secreted so rapidly that the ducts are unable to carry them away, and, as a consequence, they run over on the cheeks and reading becomes very annoying.

Let us see what is taking place during this time. The conjunctiva is becoming swollen, red and inflamed, and if a tendency to granulated eyelids exists, a rich soil is here furnished. The inflammation may also extend through the lachrymal sac to the nasal duct which communicates with the nose; swelling of the membrane lining the tube takes place, and if continued long enough remains permanently so, and the patient either has to be annoyed with tears running over the cheeks or has to go through a long and painful course of treatment for months, while if he had ceased to abuse his eyes when they warned him of approaching danger, he would, in all probability, have avoided his suffering.

This article is intended to call the attention of the reader to the fact that, in our present age, eyes are frightfully misused. It often makes me feel that some persons do not deserve to have eyes; and if these few words will be the means of one pair of eyes receiving more care and less neglect, the writer will feel well paid for his trouble.—Eclectic Medical Journal.

[FROM THE OUTLOOK.]

HEARING WITH THE EYES.

By S. MILLINGTON MILLER, M.D.

SOME ten years ago a paper was contributed to a learned society's proceedings by that distinguished inventor, Dr. A. Graham Bell. He explained at length the very curious results (statistic) of his special investigations showing that the manual method of instructing the deaf, which naturally rendered them a class by themselves, was creating a deaf and dumb species of the human race. Mr. Bell's figures indicated that thirty-three and a third per cent. of the children resulting from the union of deaf men and deaf women were born deaf, and were therefore congenitally dumb.

Much more conclusive and exhaustive figures, enforcing even more unequivocally the same conclusion, have been secured since then, and were intended for publication; but the gentleman in whose hands they were placed has not used them himself, and has not so far seen fit to permit their use by others. He is a believer in the manual method of the instruction of the deaf, and may naturally feel that the statistics which he holds form a grave argument against the very raison d'etre and permanence of that method. (It is but fair to this gentleman, Dr. Fay, of the National Gallaudet College, in Washington, D. C., to add that he has lately written to the Philadelphia Press disclaiming any intention to delay or obstruct, and promising the early publication of this interesting matter.)

The oral system of instructing the deaf enables them to read speech from lip and tongue movements, and teaches them to converse in a fairly modulated voice with the world at large. The manual method supplies a medium (the single-hand alphabet and conventional or pantomimic signs) by which the deaf may understand and converse with each other and with their teachers, but it renders them no further aid than the writing pad in their efforts to understand the general public; or to carry on an interchange of thought with it.

When it is known that one in every twelve hundred units of population is deaf, and that fully two-thirds of this total (36,000—that is, one in every eight hundred) are either born deaf or become so under two years of age, and are therefore dumb, so far as articulate speech is concerned, it will be plain that it is a matter of national sanitary importance that this unfortunate class should receive such instruction as will at once best develop their minds and least isolate them from their fellows.

There have been several methods devised for instructing the deaf. The oral method was first invented in Germany by Samuel Heinecke about the time of the French revolution. It had already been introduced into Spain in the sixteenth century by Ponce-de-Leon (no relation of the great discoverer, so far as known). The Abbe de l'Epee invented and taught the symbolical sign system in France at approximately the same date. This system consisted entirely in a natural and conventional series of mimical and symbolical signs. Savages in the earliest times conversed with each other and with strangers largely by means of pantomimic signs. The Frenchman shrugs his shoulders when he desires to convey indifference; we nod our head to indicate "yes," and shake it to signify "no;" we draw our shoulders together and shiver to show that we are chilly or cold. The Abbe de l'Epee adopted all these natural signs, and added others of his own invention which would stand for words or ideas. Taken together they formed his system.

The double-hand alphabet originated in England. It has never obtained any foothold elsewhere, and it is not by any means universally employed even there. Jean Paul Bonet originated and taught the single-hand alphabet in Spain in the first half of the seventeenth century.

There is a school in Rochester, N. Y., where the single hand alphabet method is taght to the exclusion of everything else. Other manual schools teach a combination of the most expressive and concrete signs which have survived from the system of the Abbe de l'Epee, together with the single-hand manual alphabet. By means of the more or less arbitrary letters formed by the fingers after this alphabet, words are spelled and sentences so constructed. These letters are not in all cases like the letters of the copy book, even when carefully and slowly formed, and when rapidly constructed they fail to convey the least idea to the spectator who is not an adept in the method.

Reading, writing, spelling, arithmetic, geography and other English branches are taught alike in oral and manual sign schools. The only difference between the two is that articulate speech is inculcated in one and not in the other.

The oral system teaches the deaf to speak. In a sign school articulate speech is regarded as an accomplishment. The deaf child is taught to speak primarily by accustoming the eyes to distinguish and remember the movements of the lips and tongue which accompany, or, more properly, produce, the vowel and consonant sounds separately, and then that longer or shorter series of lip movements which together form words and sentences. To assist in this education the pupil is taught to hold one hand upon the throat and the other upon the chest of his instructor, in order so to note the various and different vibrations accompanying the various letter or word sounds, and to place his hands in similar positions upon his own body while trying to imitate these sounds. If necessary, the instructor teaches the child how its lips and tongue are naturally fixed while these sounds are formed, by drawing the proper positions of the organs on the blackboard, or, in some cases, by digital manipulation of the child's lips, tongue, etc.

But when the child has grown able to articulate sounds and words by watching the movements of the instructor's lips, it has not yet learned to speak the English language. The objects whose names it has learned to sound are then pointed out to it in connection with the articulation of the name. At the same time the object itself, its written and its spoken name, are all frequently brought into close association, until the child remembers not only the sound of a name, but also its proper application. This is the task imposed upon the instructress of the first year's classes (a class usually consists of from eight to ten children), and it demands endless patience and tact. The teacher must first make the children fond of her. In the second year the child's vocabulary is increased by similar methods, and it is taught to write short letters and essays, and to describe in writing on its slate actions performed by the teacher.

In later years the various English branches are taught, so that at the end of twelve years the boy or girl can speak distinctly, write and compose correctly, and is possessed of all the accomplishments instilled at a regular school.

He who goes through one of the great oral schools sees children who can read the lips when the mouth of the speaker is turned away from them and they command only one corner of it with their eyes; who can thus read readily long and involved sentences rapidly spoken; who can even decipher the words uttered by speaking lips from their shadow thrown sharply on a white wall. Not all the graduates can do this, by any means, but it gives a fair and not an exaggerated idea of the ultimate possibilities of the system, and shows how completely and triumphantly one sense may be rendered able to perform the functions of two.

If these things be true, it must also follow that it would be possible for a gifted graduate of an oral school to enter a regular technical school or college sit in the benches with those whose senses are all perfect, hear what the professor says from watching his lips, and finally graduate and take a degree. Indeed,

the names and addresses can be given of men and women now resident in this country who were born deaf, taught at an oral school, entered a regular college, and graduated therefrom with high honors. What I have cautiously hinted at as a possibility has, therefore, been actually done in well-authenticated cases.

There is a college in Washington, D. C., supported by the national government and known as the Gallaudet College for the Deaf and Dumb. Its president is a descendant of that Dr. Thomas Hopkins Gallaudet who started the first school for the manual instruction of the deaf, at Hartford, Connecticut, in 1815.

This later Dr. Edward M. Gallaudet has so far conducted the Washington College by purely manual methods, but at a meeting held at Chautauqua the past summer he publicly expressed a willingness to complete in future the education of oral students sent to his college by purely oral instruction. This high authority's concession to the new method may, therefore, be regarded as a very significant straw in determining the direction of the wind.

There are some eighty schools in the United States devoted entirely to the education of the deaf. The pure oral method obtains in only twenty per cent. of this total. The first oral school in America was started in 1866 by Miss Harriet B. Rogers, at Chelmsford, Massachusetts, but was subsequently moved to Northampton, Massachusetts. In 1868 Dr. Philip G. Gillett, the then superintendent of the Illinois State School, introduced speech instruction into that institution. The Pennsylvania Institution began instruction in articulation in 1879, and introduced the entire oral system in 1882.

There are two distinct departments in the last named school—the manual and the oral. In the first speech is developed and made the medium of all instruction. In the second the manual single-hand alphabet and signs constitute the medium of communication and of instruction. The students of these two departments are kept isolated as much as possible, holidays never falling on the same days in the two departments. There are 265 pupils in the oral and 195 in the manual department. Since the session of 1892–93, all incoming students have been placed in the oral department, and transferred to the manual only when oral methods have been found insufficient for purposes of mental development. Very few such cases occur.

The Illinois State School for the Deaf and Dumb is the largest in the world, having over five hundred pupils. Next in point of numbers is the Pennsylvania Institute for the Deaf and Dumb.

The claim made by the believers in the newer and more advanced oral method is that it is also more direct. This word directness is, in fact, the very pith of the oralist's argument, so far as a method of instruction which brings teacher into the quickest possible accord with pupil is concerned.

But when the orally instructed deaf child leaves its school, and finds itself thrown among those who are not similarly affected, the superiority of its past education in its present environment is all the more overwhelmingly demonstrated. It meets the world at large on an equal footing. It can hear the normal speak, and answer them back in coherent, articulate words. All the duties of life can be accurately and promptly performed without any necessary discrimination against it, and in the company of those who hear. And the tenderest relation of life may be found in the general ranks of society, and a happy union result without any disability. The manual graduate can make himself understood in the midst of a general conversation only by means of a writing pad.

RECRUITING FOR THE CHINESE ARMY.—DRAWN BY PAUL FRENZENY.

RECRUITING FOR THE CHINESE ARMY.

THE Chinese regular army, from which the garrisons of Pekin, Tientsin, and the provincial capitals are drawn, musters considerably less than 100,000 men altogether. The only reserve force is that of the Ying-Ping, or national militia, sometimes called the "Green Flags" or the "Braves;" of whom, possibly, in the eighteen provinces, 170,000 might be called out for service, but undrilled, and mostly armed with hatchets, pikes, bows and arrows, and "jingals" or heavy matchlocks. Some of these raw levies have, in their march toward the seat of war, perpetrated robberies and murders and other outrages. They are more to be dreaded than the Japanese soldiers.

The mode of recruiting for the Chinese army is shown in our engraving, for which we are indebted to the Illustrated London News. It is on the same system as that in vogue in England one hundred years or more ago, and known as the press gang. In China a gang of cavalry goes about and captures every able-bodied man they can catch. The victims are yoked together like African slaves and in this way dragged off to the military stations, where they are compelled to serve in the army. Naturally, they flee at the first opportunity.

THE POSITION OF WOMEN IN GERMANY.

THE position of women in Germany is one which may well awaken a feeling akin to despair in the heart of the social reformer. In no country in Europe, except perhaps Turkey, is the general condition of woman so degraded, and in no country, it may be safely said, does she acquiesce so tamely in her degradation. The Empress Frederic, to her honor be it recorded, made heroic efforts to raise the status of women in the upper classes of society, and endeavored to insist that more deference should be paid to them and that their intellectual and social equality should be recognized. How far she would have succeeded, had the brief reign of one hundred days been prolonged, it is impossible to say; the immediate result was that the "Englishwoman" got herself cordially disliked, and, strangely enough, some of her cruelest detractors were among the sex whom she had striven to emancipate. In the direction of the higher education of women the efforts of the Empress Frederic have borne some fruit. This is evidenced by the recent triumphs of women at the University of Heidelberg, and by the institutions which have been founded for their benefit in Saxony and Bavaria. But the movement has only touched a small section of German women of the upper classes—and a very small section even there. Even in the highest circles of German society, woman is regarded from the barbarian point of view. The wives of the majority of the German nobility are mere housewives, upper servants, whose duty it is to look after the material comforts of their lords and masters. A wife is not regarded as an equal or a companion, but a mere housekeeper, and producer of children. Her "sphere" is the kitchen and the nursery, and there she must abide. Madame de Stael once asked Napoleon who was the greatest woman in the world? He replied brutally, "The woman who has borne and reared the greatest number of male children." This frame of mind exactly expresses the light in which most German husbands regard their wives, and it may be added, the view in which German women regard one another. It is a state of affairs which brings its own punishment, for the women are often so unendurably dull and soulless, that the men are driven for companionship to "restauration" and mess rooms, and society in Berlin—to name one city only—is utterly lacking in that elan and refinement which is found, at least on the surface, in other capitals of Europe.

And this is equally true of the middle and lower classes. Here, the results of this system of the degradation of women are even more marked—at least outwardly. Among the bourgeoisie the wife and mother is a mere propagative drudge, there is no other word for it. As soon as she is married she is turned into the kitchen, and in the kitchen she remains, except when she is bearing children. She generally loses all her good looks within the first year of marriage, neglects her dress and personal appearance, and degenerates into a slattern. Her one function in life is to minister to the appetites of her husband, and as a reward she is sometimes graciously allowed to dine at the same table with him on Sunday, and occasionally on high days and holidays to trudge with him and her children to some beer garden. There she may be seen sitting over her beer, a flaccid, soulless, sodden thing, occupied even then with her everlasting knitting, and rarely exchanging a word with her "lord and master." That this is no exaggerated picture of the German middle class woman may be proved by visiting on a Sunday afternoon any of the places of public resort in a German town. Hundreds of women, with or without their husbands, may be seen there exactly as described. The English, it is said, take their pleasures sadly, but these! Mental and intellectual enjoyment they have none, and can have none. Their pleasures are of a piece with their lives.

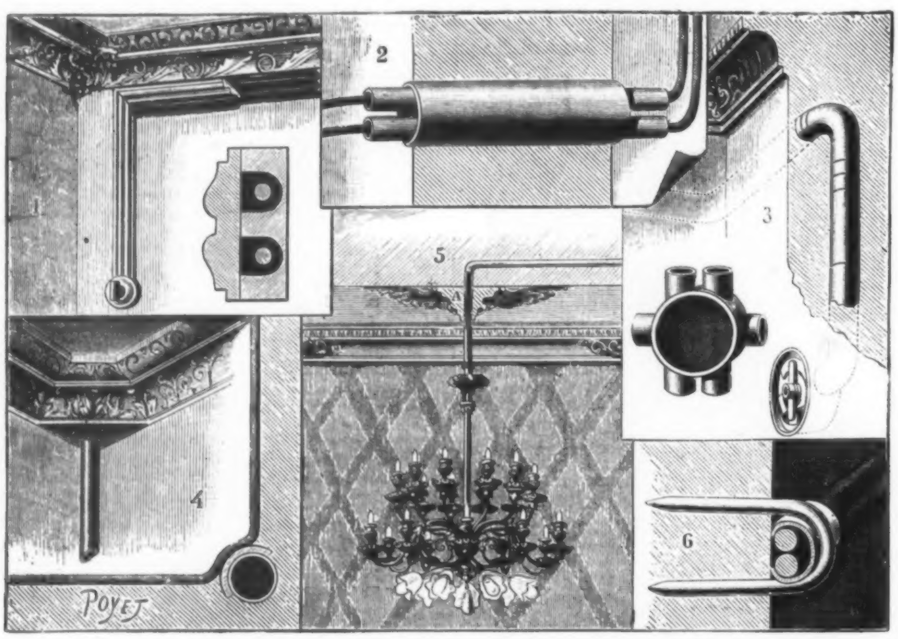
Among the peasant class of Germany the woman is treated literally and actually as if she were a mere beast of burden. In the rural districts she is a hewer of wood and drawer of water, doing manual labor as laborious as that of any man, and without a man's privileges or a man's wages. This is in some sort to be accounted for by the military service which calls away the young and active men from agricultural pursuits, and leaves much of the work to be done by women. In England we are by no means unfamiliar with the sight of women laboring in the fields and in the lighter forms of husbandry, and this is doubtless far less hurtful, physically, to country women than the long hours of labor in the sweater's den to which their town sisters are too often doomed; but in Germany the heaviest agricultural work is often undertaken by women; in fact, she has to do what in civilized countries is generally allotted to the beasts. To quote two instances attested on the best authority given by an eye witness. In the Rhine Valley, not far from Bingen, last August, two women, one middle-aged, the other younger, were dragging a plow which was guided by a man. Half a small field had been plowed in this way, and they hoped to finish before nightfall. The women were doing the work which horses do in this country, and the man was guiding the plow and shouting to them as though they were horses. None of the trio seemed to see anything strange in this proceeding; it was their own plot of ground, and the labor was voluntary on the women's part. Again, a week later, just outside the town of Freiburg, in Hesse, the same eye witness met a cart loaded with hay drawn by an ox and a young woman, both harnessed to the cart. A man was walking alongside! In reply to inquiries it appeared that the young woman was the man's daughter. Upon being remonstrated with he seemed to see nothing unusual in the circumstance, and remarked that when the girl was tired he should take a turn himself. The girl, however, was evidently rebellious. These two instances, by no means exceptional ones, will serve to illustrate the condition of the German peasant women. Their lives are one ceaseless round of unremunerative toil, and, in many instances, the hard labor to which they are subjected renders them altogether unfitted for the duties of maternity, and seriously impairs their health. It may be doubted whether in any other country of Europe the condition of the peasant woman

is so low. In France and Russia, for example, they may work almost as hard, perhaps quite as hard, but, at least, their work is recognized by their husbands and male relatives, and they are in a sense helpmates and receive a due amount of consideration as such. But in Germany their position is always one of inferiority to the man, and their toil is treated as a matter of course.

The results of this system of the degradation of women is very marked through all classes of society in Germany. In the upper classes there is no society in the sense that we understand it. How can there be when woman is persistently treated as man's social and intellectual inferior? She is either a toy or a drudge; and in refinement and manners, in all the graces which the presence of cultured woman brings, German society is sadly lacking. The artistic sense is also wanting, and this is evidenced in the unlovely dress of the women, the crude and barbarous decorations of the houses, and in a hundred and one other little ways which can hardly be enumerated. In the middle classes there is wanting that bond of union which makes up family life. How can it be otherwise when she who should be the presiding genius of the home, the wife and the mother, occupies a position of perpetual inferiority to her husband and her sons? And among the peasantry the woman is a slave without a slave's compensation. The hard physical labor which she has to perform too often exercises an injurious effect upon her health, and upon the health of her children. That the degradation of woman involves the brutalizing of man is nowhere more apparent than in Germany. And yet Germany professes to be a civilized and enlightened nation!—The Humanitarian.

FRENCH METHODS OF ELECTRIC LIGHT INSTALLATION.

ELECTRICITY is largely used in private houses, where the greatest precautions must be observed to guard against fire. The experience of the last few years has enabled us to decide upon the preferable methods of installation. Channeled mouldings are extensively used, as well as iron hooks insulated with porcelain and tubes of compressed paper. In the French method of installation the wooden moulding shown in Fig. 1 is extensively used; the mouldings are made in two parts, the lower being channeled to receive the conductors, which are themselves insulated. An ornamental covering closes the opening. In general the lower part which receives the wires is fireproofed and coated with paraffine to insure better insulation. Occasionally, as in Fig. 6, the wires are not inclosed, but are secured by a staple and insulated with a band of rubber. Porcelain insulators in walls are excellent, especially where the walls are humid, but their use is limited in apartments where appearances must be respected. The Bergmann Company, of Berlin, have lately been making a very satisfactory paper tube, which is built into the walls when the houses are constructed, and the wires put in at a later time. Fig. 3 shows the tubes in the walls and a distributing box.



FRENCH METHODS OF ELECTRIC LIGHT INSTALLATION.

The greatest precautions must be taken in installing electric wires to guard against fire, especially in large cities, where at any minute the wire may become grounded or short-circuited by the pipes for gas, water or compressed air. To avoid this danger the simplest plan is to have all the pipes and wires arranged parallel, avoiding all crossings. If the cables are simply isolated from the metal pipes by the insulation, they should be inclosed in rubber or gutta percha tubes and carefully insulated, as shown in Fig. 4, which shows a gas pipe and a moulding containing the electric cables. The wires should be inclosed in rubber tubes, which are placed in a metal tube when a wall is to be penetrated, as shown in Fig. 2. In Fig. 5 we have an example of a combined chandelier for gas and electricity. All danger of grounding is prevented by having a break in the tube. This break occurs in the center piece, as shown at the point, A. For our illustrations and for the foregoing particulars we are indebted to La Nature.

A WRITER in a Philadelphia paper asserts that the Eastern cities, by boring artesian wells, can tap underground rivers from the Alleghanies and thus secure a pure and bountiful supply of water.

CONSTITUTION OF THE ELECTRIC ARC.

By L. THOMAS.

THE production of interference fringes with the light of the arc shows that a region near the negative pole is plainly monochromatic. If we simultaneously illuminate one-half of the field with the arc and the other with a flame charged with sodium, we find that the two series of fringes agree exactly. The phenomenon is therefore due to the great brightness which the sodium vapor acquires near the negative pole, relatively to the other gases present. We further recognize that it is on setting out from the negative pole that the vapor expands itself in the exterior flame.

There is room to suppose that this accumulation at the negative pole is not peculiar to sodium, but for the other substances the question can only be treated by means of the spectroscope. Now the modifications undergone by the metallic rays in different parts of the arc will be, according to Lockyer, most irregular, a substance showing at the same time certain rays near the positive pole, others near the negative pole, and others only in the intermediate region.

I have taken up this study having regard to the two following points:

1. A modification in one ray cannot be certainly referred to a particular region of the source (of light) unless the image of such source, being projected on the plane of the slit, yields in the spectroscope for each point of the slit a linear spectrum; that is to say, we must realize the aplanatic regulation indicated by Cornu in his beautiful memoir on the groups A, B, a, of the solar spectrum, and which complete so usefully the method of Lockyer.

2. To escape the frequent modification of the arc it is convenient to reduce the observations to the shortest possible duration, and to this end it is sufficient to photograph the region of the maximum of sensitiveness of the plates.

The carbons employed are either ordinary carbons, the impurities in which are especially compounds of iron and calcium, or carbons with a core formed of a mixture of charcoal powder and a metallic salt. The latter, if the mixture is thorough and the proportion of the salt not too considerable, allow us to obtain very constant spectra.

The following are the facts observed:

I. SLIT PARALLEL TO THE CARBONS, DIVIDING THE ARC INTO TWO EQUAL PARTS.

The metallic lines, visible over all the height, increase the luster and the breadth from the positive to the negative. This increase is abruptly exaggerated in the neighborhood of the latter; the lines which occupy only a part of the height extend to the negative; the inversion, when it occurs, is most marked near the negative; lastly, while some lines only extend over the interval of the carbons with little luster, almost all traverse the negative and are extinguished only at some distance.

II. SLIT PARALLEL TO THE CARBONS, OUTSIDE THE BRILLIANT CIRCLE WHICH TERMINATES THE NEGATIVE.

The spectrum is divided into two parts, situate at different levels: resting upon the positive carbon the spectrum of Swan, and the spectrum of cyanogen, and beyond the spectrum of the metallic vapors, presenting its maximum luster near the level, where the lines of the first terminate in fine points.

III. SLIT PERPENDICULAR TO THE CARBONS.

The metallic rays extend much further than the lines of the band spectrum. The latter have the form of a breadth constantly decreasing from the middle to the ends, whatever may be the position of the slit between the two carbons. The metallic lines have the same form near the negative. Everywhere else they have a constant breadth, except the points of the extremities.

Hence it is easy to understand the frequent changes observed from moment to moment on a direct examination of the spectrum, and the reason of the irregularities pointed out by Lockyer, and of some peculiarities which it would be too tedious to describe here.

Lastly, we see outside the arc, and principally near the negative pole, spectra of metallic oxides; the bands of calcium and barium are especially brilliant.

The totality of the facts is thus interpreted: The arc formed of a mean length between two carbons containing metallic salts consists of a core and a covering. In the core are found the substances which give off band spectra, carbides or vapors of carbides, and cyanogen; in the covering, the metallic vapors derived from dissociated salts circulate from the positive to the negative carbon. The metallic molecules, after this electrolytic transportation to the negative pole, combine with the oxygen of the air and escape in the flame.

I have succeeded in obtaining a photograph of this stratum by placing before the object lens a trough filled with fluorescein. The division is distinctly marked, in consequence of the partial solarization of the proofs; the stratum alone is black; the core and the two brilliant surfaces which terminate the carbons are solarized. An interesting point is that the stratum cuts the negative carbon perpendicularly to the direction of the carbon, which is favorable to the spectroscopic study of the velocity of the mols. at the extremity of their track. This part of the covering presents deviations in the metallic lines, but, at least with the dispersions which I have been able to employ, these deviations are annulled at the same time as the astigmatism of the spectroscope.

From the above we may explain the differences of luster and form of the two poles. Although no experiment proves the afflux of the elements of the air to the positive pole (except perhaps the presence of cyanogen in the core), it is nevertheless very probable, and must employ an important part in the elevation of the temperature of this pole. The arc will thus be a sort of gas voltameter. The positive carbon will be attacked by the gases brought up by the current, while the negative carbon will be protected from the access of air by the metallic vapors.

In support of this view I will cite the following facts:

In a very rarefied atmosphere the sections of the arc near the two poles are sensibly equal; in hydrogen, under a pressure of about 10 cm., we find a greater luster of Ha Hβ near the negative pole.

In coal gas, in an hour, the arc deposits upon the positive carbon a considerable and regular deposit of very compact carbon; the negative carbon shows a great number of craters.

If the positive carbon is covered with strontium chloride, the arc is stable only when the negative carbon is cut into a cylinder of small dimensions, rounded at the end, and the lateral surface of which the layer of strontium vapor is normally placed.—Comptes Rendus, cxix., p. 728; Chem. News.

UTILIZATION OF CHEMICAL ENERGY FOR THE PRODUCTION OF ELECTRICITY.

IN a paper read before the Deutsche Electrochemische Gesellschaft last month, Dr. W. Borchers describes some interesting experiments he has been making on the direct production of electricity from coal and combustible gases.

His first experiments were made with carbonic oxide gas, but he also succeeded in producing an electric current by the combustion of hydrogen, hydrocarbon gases, and even from pulverized coal. His great invention, however, is the use of cuprous chloride as the electrolyte in his battery. It is well known that cuprous chloride is a good absorbent for both carbonic oxide and oxygen. It appears natural, therefore, to suppose that it will form a suitable electrolyte to promote chemical combination in a gas battery, with carbonic oxide and oxygen as its elements.

The first apparatus was made of any glass or stoneware vessel to hand, which could be conveniently divided into two compartments, communicating at the bottom. The vessel was partly filled with an ammoniacal or acid solution of cuprous chloride, air was supplied to one compartment and carbonic oxide to the other. When the carbon poles, with which the compartments were furnished, were connected, a weak electric current was obtained. By placing pieces of coke in the cells, and thus increasing the surface of contact between the gas and the liquid, a considerable increase in the strength of the current was obtained. The results of this first experiment, if not exactly discouraging, were far from being up to expectation.

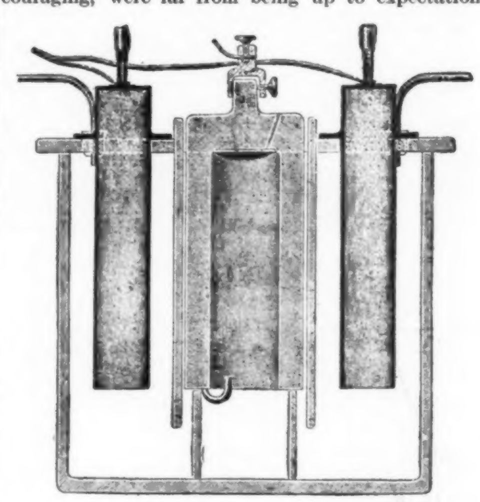


FIG. 1.

Platinum poles would probably have given a better effect than carbon, but the use of this metal was forbidden by its price. It then occurred to the author that copper might be safely used as a pole in the carbonic oxide cell, the probability being that it would not be dissolved, since carbonic oxide precipitates copper from cuprous salts. This supposition was found by experiment to be correct, and it thus became practicable to make the vessel containing the electrolyte of copper, and to connect to it one of the terminals of the external circuit.

The preliminary apparatus by which these points were established is shown in Fig. 1. A glass vessel

was divided into three compartments by two glass plates which did not reach quite to the bottom. In both the exterior compartments copper tubes were suspended for the introduction of the carbonic oxide gas. In the middle compartment, a carbon bell dipped, for the introduction of air. A solution of cuprous chloride was used as the electrolyte. The copper tubes were weighed. The carbonic oxide cells were protected against the entrance of air by lids. The carbonic oxide, which was used in the first experiments, was afterward, for convenience, replaced by coal gas, which contained at least 5 per cent. of the former. No decrease in the weight of the copper was at any time ascertained; on the contrary, on one occasion a slight increase was observed.

Acid solutions of cuprous chloride gave better results than alkaline solutions. Table I. gives the results of measurements made when carbonic oxide strongly contaminated with carbonic acid, and acid solution of cuprous chloride, and air, were used in the battery.

TABLE I.

External resistance in ohms.	E.M.F. in volts.	Current strength in amperes.
0·1	0·05	0·5
0·1	0·20	0·20
0·2	0·23	0·13
0·3	0·25	0·10
0·4	0·275	0·075
0·5	....	0·060
0·7	...	0·050
10	0·300	0·040
15	..	0·028
20	0·400	0·020
25	....	0·015
30	. .	0·012
40	....	0·010
50	0·400	0·008

To facilitate the absorption of carbonic oxide by exposing a greater surface of contact, the external cells

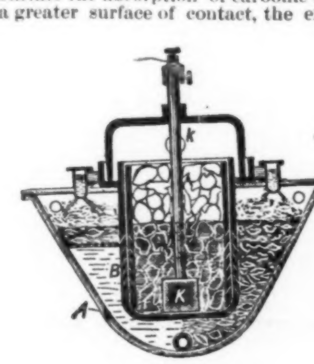


FIG. 2.

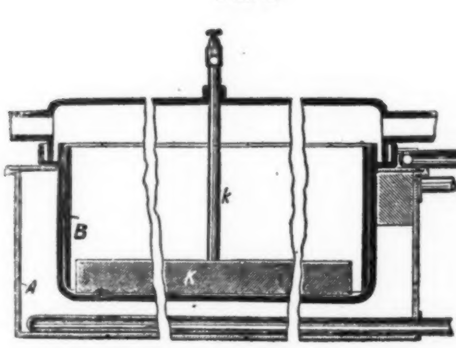


FIG. 3.

were filled with copper clippings. By using at the same time a gas corresponding in composition to generator gas, a current of as much as 0·64 ampere was obtained on short circuit, while by gradually increasing the external resistance a maximum value for the E.M.F. of 0·56 volt was reached.

This result, to be sure, is not to be characterized as in every respect favorable, since the E.M.F. calculated from the chemical combination of carbonic oxide on oxygen alone is 1·47 volts. From the results of the experiments given above as compared with the maximum theoretical voltage, at least 27 per cent. of the energy of the fuel is converted into electricity. By the use of a gas among whose combustible constituents are, besides carbonic oxide, hydrogen and hydrocarbons, the effect appears to be still more favorable. According as the lowest or highest values of these combustibles are taken, the electric energy produced is 38 per cent., or 26 per cent. of the energy of chemical combination. If, therefore, in a comparatively incomplete apparatus one-quarter to one third of the chemical energy of the fuel can be converted into electricity, this success may well give encouragement to further efforts.

It is well known that a solution of cuprous chloride also dissolves hydrocarbons. It may not therefore be necessary to convert the fuel into carbonic oxide. Powdered coal was tried in the above apparatus instead of carbonic oxide, and the strength of current and E.M.F. obtained were not far behind those obtained with gaseous fuel. A maximum E.M.F. of 0·3 volt and a maximum current of 0·4 ampere was obtained.

The oxidation of carbon corresponds to a theoretical voltage of 2 volts; thus 0·3 volt corresponds to an efficiency of 15 per cent. Even with considerable motion in the liquid a falling off in the current soon takes place with coal dust, and this has never been observed with the use of carbonic oxide, or coal gas. The gradual pollution of the liquid with the use of coal would forbid its use even with a more favorable efficiency. The author considers that the use of the gas element is the only way by which success is likely to be attained.

The most recent design of the gaseous fuel element elaborated by the author after the trial of many forms is shown in Figs. 2 and 3. The external vessel, A, is of copper and contains the cuprous chloride electrolyte. The inner vessel, B, is of earthenware with double sides which are perforated, and contains the space for the cathode. The space between the double sides may be filled with a porous material if necessary. The vessel, A, is furnished with a lid having two holes for the inlet and outlet of the gas, and an aperture in the center through which a carbon rod, k, passes down to the carbon plate, K. The space above the carbon plate may be filled with broken coke to increase the surface of contact. For the same reason, the outer vessel is filled with clippings of copper. The cuprous chloride is supplied by channels running along the lid of the external vessel, A, and drawn off by a pipe at the bottom of the vessel.

The gas and the electrolyte can thus be circulated through a series of cells in a large battery. Pipes are also fitted to circulate air in the upper part of the copper vessel. The author also describes a form of cell adapted for the combustion of powdered coal. The latest form of the gas element described above has not yet been tested, being still in the course of construction.—The Electrical Review.

APPARATUS FOR EXPERIMENTING WITH HIGH TEMPERATURES.

IT is a well known fact that it is very difficult to heat a body to a high degree in the midst of a compressed gas. The apparatus constructed several years ago by M. Cailletet, the celebrated French physicist, permits of carrying a body to a temperature bordering that of the fusion of platinum and maintaining it in a gaseous atmosphere, the nature of which, as well as the pressure, may be varied at will. This apparatus consists of a mass of steel, A (Fig. 2), which is bored to receive the mechanism for fusing. The

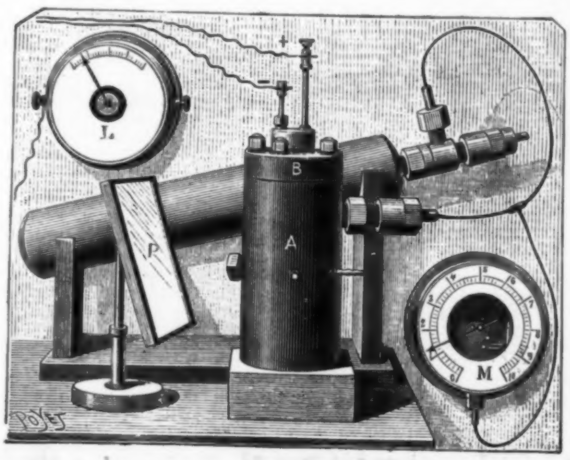


FIG. 1.—CAILLETET'S APPARATUS.
A, steel cylinder with cover, B; P, mirror; M, pressure gauge; L, amperemeter.

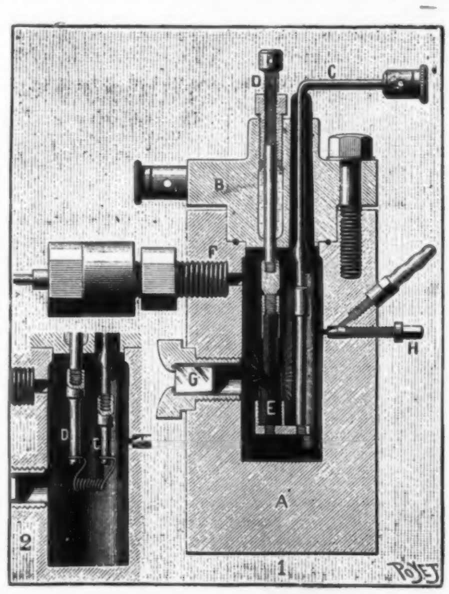


FIG. 2.—SECTION OF THE APPARATUS.

top, B, is penetrated by two wires, one of which, C, is insulated; the wire, D, is adjustable. To the bottom of C is secured a platinum holder or crucible, C, in which the substances are placed which are to be experimented upon, or a small coil of platinum wire may be used, as shown in the small cut in Fig. 2; thus forming a kind of muffle which receives the body to be operated upon. A fragment of gold placed in the spiral is melted in a few moments. The copper rods or wires are adapted to receive carbons, and storage batteries may be used to furnish the current. The block of steel is pierced by an orifice, F, connected by a capillary tube with a reservoir or cylinder containing gas under pressure. The small opening, G, is used to watch the progress of the operation. To avoid danger of the eyes being injured if the glass breaks, an inclined mirror is used to observe the experiment. In case it is desired to use the gas contained in the steel block, or furnace, for purposes of analysis, it may be drawn off by unscrewing H. The gas is compressed into cylinders in the usual way with the aid of a pump. A metallic manometer fixed to the apparatus permits the slightest variation in pressure to be observed and to regulate its refrigerating effect upon the body which is being heated by the current of electricity.

The current which would bring the platinum to the point of fusion only brings it to a dull red when the pressure is sufficiently great. M. Cailletet has performed with his apparatus the classic experiment of Hall on carbonate of lime. A fragment of chalk heated in the platinum spiral diminishes sensibly in volume and is transformed into a reddish brown body which dissolves slowly in acids, disengaging carbonic acid. For our illustrations and the foregoing particulars we are indebted to La Nature.

PHOSPHORESCENCE AND PHOTOGRAPHIC ACTION AT THE TEMPERATURE OF BOILING LIQUID AIR.*

By JAMES DEWAR, F.R.S.

PHOSPHORESCENCE and fluorescence are terms applied to similar phenomena which apparently differ only in degree, the first lasting for a relatively long period after the withdrawal of the light stimulus, whereas the second is so short that it can only be observed during the continuous action of the exciting agent. In all cases the luminous effects called phosphorescence and fluorescence belong to a less refrangible part of the spectrum than the exciting rays. Phosphorescence may be regarded as a kind of fluorescence which lasts a long time after the excitation has ceased; and may be briefly described as the phenomena observed when certain substances give out light through the transformation of absorbed vibrations of shorter period. The researches of Becquerel showed that the intensity of phosphorescence depended directly on the intensity of the stimulating light, and a factor of absorption and intensity as some coefficient representing molecular friction or damping. When phosphorescing sulphides of calcium are heated they increase in this light emission, whereas if they are cooled to −80° they cease altogether to be luminous, and if maintained at this low temperature for hours keep a latent store of light energy that may be again evolved on allowing the temperature of the sulphide to rise to the ordinary temperature. But while the temperature of −80° is sufficient to stop all sensible emission from previously excited sulphide, it does not prevent an unexcited sulphide from absorbing light energy that can be evolved at higher temperatures. Having now the means of cooling substances to temperatures ranging from −180° to −200° by means of liquid air, a new study of phosphorescence seemed admissible. Under such conditions all known organic compounds are solids, and this condition of matter is specially favorable to phosphorescent phenomena.

The effect of temperature on phosphorescence is easy to observe by taking two portions of the same substance placed in similar very thin test tubes, cooling one of the specimens in liquid air, and then quickly exposing both samples side by side to the same light stimulation. If during the light excitation, caused by burning magnesium or a flash of the electric light, the eyes are carefully covered, then the comparative phosphorescence, if any, of the cooled and uncooled substance can be observed. In this mode of working the action of the very short wave lengths of light are stopped by the opacity of glass, but the solid condition of all substances at low temperature enables the use of glass to be abandoned when necessary. As a general rule it may be stated that the great majority of substances exhibiting feeble phosphorescence at ordinary temperatures become markedly more active at these very low temperatures. Thus gelatine, celluloid, paraffine, ivory, horn, and India rubber become distinctly luminous with a bluish or greenish phosphorescence after cooling to −180° and being stimulated by the electric light. Hydroquinone was more luminous than the isomeric resorcinol or pyrocatechol, and in the same way pyrogallol was faint compared with phloroglucol. All alkaloids forming fluorescent solutions become phosphorescent at low temperatures. The hydrocarbons, alcohols, acids, and ethers of the fatty series are all more or less active, and glycerine, sulphuric

* At a recent meeting of the Chemical Society, London, this paper was read and experimentally illustrated.

and nitric acids are all very bright, so also are concentrated hydrochloric acid and strong ammonia solution. Colored salts generally show little activity, but a large number of colorless salts are very luminous. Water when pure is only feebly phosphorescent, but remarkably so when impure. Acetic acid and acetamide appeared fairly equal in luminosity; hippuric acid was very fine, as were most substances containing a ketone group. Lithium platinocyanide changed from white to red on cooling, and was excelled in phosphorescing power by yellow ammonium platinocyanide, which was exceedingly bright.

Definite organic substances possessing exceptional powers of phosphorescence when stimulated at $-180°$ C. are acetophenone, benzophenone, asparagin, hippuric acid, phthalic anhydride, urea, creatine, urethane, succinimide, triphenyl methane, diphenyl, salicylic acid, glycogen, aldehyd-ammonia, etc. It will require long and laborious experiments, however, to measure the relative brightness of the phosphorescence of bodies belonging to definite series.

Remarkable results were obtained with an egg shell and a feather respectively. The egg shone brilliantly as a globe of blue light, and the feather was equally brilliant, its outline showing clearly in the darkened room. Other organic substances giving good results were cotton, wool, paper, leather, linen, tortoise shell, and sponge, all phosphorescing brightly, as did also a white flower, a cultivated species of Dianthus. Colored glasses and papers as a rule exhibit no phosphorescence, and when the alcohols are colored by the addition of a trace of iodine the luminous effect is destroyed. Milk was shown to be highly phosphorescent and much brighter than water. The white of egg has greater phosphorescing power than the yolk, white substances generally being superior in this respect to colored ones. On cooling a layer of white of egg on the outside of a test tube to $-190°$ and then exposing it to a flash of the electric arc, the brilliancy of the phosphorescent light is very striking. The chloro-, bromo-, iodo-, sulpho-, and nitro compounds, as a rule, show nothing, or are but faintly luminous. Among basic bodies, nicotine is more luminous than quinoline or pyridine. Metals also phosphoresce, but in this case the action is due to some organic film deposited from the air, because it disappears on ignition. If the metal is subsequently touched, the phosphorescence reappears.

So far as the examination has been carried, the two most remarkable classes of substance for phosphorescence are the platinocyanides among inorganic compounds, and the ketonic compounds, like acetophenone and ethyl phenyl ketone, and others of the same type among organic. When ammonium platinocyanide is cooled with liquid air and maintained at this temperature by being immersed in the liquid while stimulated by exposure to a beam of the electric arc, it continues to glow in the dark with a feeble emission as long as the temperature is kept about -180. On pouring off, however, the liquid air from the crystals, so that the temperature may rise, then the interior of the test tube glows like a lamp from the sudden increase of light emissivity as the temperature rises. It seems clear from this experiment that similar initial light intensities being used for stimulating, the substance at this low temperature must have acquired increased power of absorption, and it may be that at the same time the factor of molecular friction or damping may have diminished. That the absorptive power of substances for light is greatly changed at low temperatures is proved by the change of color in substances like oxide, iodide, and sulphide of mercury, chromic acid, etc., when cooled. Many quantitative photometric measurements must be made before the actual changes taking place in the conditions governing the phenomena can be definitely stated.

Along with these experiments on phosphorescence, a number of photographs have been taken at $-180°$, using various sensitive plates and films, and these have been compared with similar photographs taken at the same time under similar conditions at the ordinary temperature. The photographs have been examined by Captain Abney, who reports that the photographic action has been reduced by 80 per cent. at the temperature of -180. If the photographic action is brought about by a chemical change, then it appears to be the only one that can be traced under such conditions, as substances having the most powerful affinities have no action on each other, and all voltaic combinations cease to give a current at such low temperatures. It is certain that the Eastman film cooled to $-200°$ by the evaporation of air in vacuo is still fairly sensitive to photographic action. Much further work, however, will be required to reach a definite conclusion as to what is taking place when substances sensitive to photographic action are subjected to such conditions of temperature.—Chem. News.

LOSS OF HEAT BY IMPERFECT COMBUSTION.

By W. A. Dixon, F.I.C., F.C.S., Tech. Coll., Sydney, N. S. W.

Tatlock, in the Chemical News (vol. lxx., p. 51), on the "Heating-power of Smoke," shows that the amount of heat which is lost, through the incomplete combustion of coal, in the form of unconsumed carbon, is so small as to be practically negligible. He, like most others, assumes that the loss of heat is due entirely to this unconsumed carbon, which is not the case. Tested by the calorimeter, fairly good coal shows an evaporative power of about 13 lb. of water for 1 lb. of coal on an average, while in actual working the effect is seldom more than 8 lb., and often less, so that there are 5 lb. or more to be accounted for. This is partly used for the production of chimney draught, and partly lost in radiation, and it is evident that all heat passing into the chimney beyond that necessary for draught is wasted.

The production of smoke promotes this waste in two ways: first by depositing a non-conducting coating of soot on the boiler and tubes; and second, by the suspended smoke not acting as a screen to the radiant heat from the fire, so that the escaping gases are unduly heated. It is well known to engineers that the steam raised from the radiant fuel in the firebox, or from flame, gives the greater portion of the effect in a boiler, and any screen would of course diminish this. That smoke acts as such a screen I have often noticed when, being in sunshine, a cloud of smoke from a steamboat funnel has passed so as to form a cloud, when you immediately feel the effect of the shade. I have also found experimentally that the temperature of a reverberatory furnace is much increased by admitting air, so that smoke disappears, while the flame is kept a reducing one.

The analyses of furnace gases given by Tatlock show that three times the necessary quantity of air was passing through the furnace; but even if the necessary quantity only was used, the rise in the temperature of the gases caused by the smoke preventing the passage of the heat into the boiler would cause great loss.—Chemical News.

EXPLOSION OF ACETYLENE AND OXYGEN.

Prof. Lothar Meyer communicates to the Berichte, says Nature, a warning note concerning the dangerous nature of explosive mixtures of acetylene and oxygen. It is a well-known fact, frequently demonstrated upon chemical lecture tables, that detonating mixtures of hydrogen and oxygen, or of marsh gas, ethylene, or carbon monoxide and oxygen, may be ignited in an open glass cylinder without danger, provided the vessel is not narrowed at the neck, which would be likely to cause undue pressure. Prof. Meyer states that he has frequently performed the experiment with the above gaseous mixtures, employing a strong straight glass cylinder four centimeters wide and with very thick base, without ever having experienced an accident. Upon performing the experiment recently, however, with a mixture of acetylene and two and a half to three times its volume of oxygen, igniting the gas by approaching the mouth of the cylinder to a flame, the cylinder was blown to innumerable fragments in his hand, happily and almost miraculously without injuring him, although unprotected by a cloth, and the report of the explosion was so loud as to deafen for a time those in the neighborhood. It has long been known that acetylene explodes with oxygen in closed vessels with great violence, frequently destroying an eudiometer, but this remarkable destruction of an open cylinder is a new evidence of its disruptive force. In the year 1884 Prof. Meyer, in conjunction with Prof. Seubert, showed that the detonating mixture of acetylene and oxygen ignites at a lower pressure than all other combustible gases, a pressure equal to thirty-two millimeters of mercury being sufficient to enable it to explode, while hydrogen and oxygen require a pressure of at least one hundred millimeters, and carbon monoxide and oxygen over two hundred millimeters. This, however, is not sufficient to account for the enormous pressure developed in an open cylinder. Moreover, it cannot be due to the more rapid rate of propagation of the explosion, for M. Berthelot and Prof. Dixon have independently found that the rapidity in the case of the acetylene detonating mixture is but slightly greater than in the mixtures of oxygen with ethylene or marsh gas, and much less than in the case of a mixture of hydrogen and oxygen. Prof. Meyer suggests that the smaller amount of hydrogen contained in acetylene than the other hydrocarbons, resulting in the production of less water vapor and relatively more carbon dioxide, together with the fact that the theoretical temperature of the combustion calculated from existing thermal data is extremely high in the case of acetylene, may afford some explanation of the extraordinary energy developed during the explosion of the latter.

THE MUTTON FREEZING INDUSTRY.*

By Herbert Gibson.

To the producer in all parts of the globe, the question of how to dispose of the fruits of his labor is one of first importance. That country is most felicitous in commerce which can combine a maximum facility in producing necessary supply with a facile and economical communication with the centers of demand. In this respect the Argentine Republic stands preeminent; and while on the one hand its fertile properties guarantee a most plentiful and secure harvest of raw material, so on the other its geographical position and physical contour place it closely in touch with the consuming world. In a preceding chapter it has been shown at what cheap rates mutton and wool can be grown; it remains for this chapter to prove how the producer can find a market for his wares.

The Meat Freezing Trade.—In the whole annals of the history of sheep in the great pastoral colonies of the world, no innovation has so completely revolutionized and furthered the interests of the sheep breeding industry as the introduction of the freezing of mutton for remission to Europe, and sale there. Looking back upon the days before this exit for the sale of surplus bleaters was discovered, it seems impossible that the breeder of sheep could have looked forward to the multiplication of his flocks with anything but the gloomiest forebodings for his future prospects. By 1882 a fall in the price of tallow had become gravely accentuated, and the value of sheep skins had also taken a downward road. Local consumption answered for but a small fraction of the annual increase, and although there still remained—as there remains to-day—great virgin tracts ready to be turned into pasture land, the breeder had but a poor prospect of making a sufficient income to enable him to enlarge his territorial possessions. Just as in 1843 the industry of boiling down sheep for their tallow and skins solved a difficult economical problem, and sent up the value of sheep, so in 1883, when produce had already fallen greatly, and the horizon of the breeder was at its gloomiest, the freezing trade supplied the want, and found a market for the comparatively valueless wethers. Sheep until then were bred for little else than the value of their wool; now, the question of mutton has made the breeder as scrupulous about the fattening and early maturing qualities of his stock as he is about the length and fineness of the staple of the fleece.

By 1883 Messrs. Drabble Brothers in Campana, and Messrs. S. G. Sansinena & Co., of Barracas, had completed their buildings, laid in their machinery, and started to freeze mutton for shipment to Europe. In that year the number of carcasses sent home to the old world, principally to England, barely passed 17,000. The writer visited the establishment of Messrs. Drabble that year, and can well remember the imposing and novel sight the freezing rooms offered, with their long rows of sheep's carcasses, swathed in spotlessly clean linen as in their winding sheets, and disappearing in the dim perspective of the snow-covered chamber. Since that date the trade has assumed titanic proportions, and one single freezing company exports more in a fortnight than did the whole trade during the twelve months of that year. Improvements have brought the business to such a nice perfection to-day, that the frozen carcasses have an appearance of cleanliness and wholesomeness for which one might search in vain through all the butchers' shops in Buenos Ayres. There now exist no less than five immense establishments in the Argentine Republic for the freezing of mutton, capable of exporting up to 3,000,000 carcasses per annum.

In 1891 the number of carcasses exported from the Argentine reached 1,200,000, this number being more than one-third of the total number of carcasses frozen annually in the world, and representing 6 per cent. of the total annual consumption of the United Kingdom of Britain. In 1892 the following was the exportation of frozen mutton:

The Sansinena Co.	408,688
Nelson's New River Plate Meat Co., Limited	450,444
The River Plate Fresh Meat Co., Limited	345,190
O'Connor & Co.	90,022
	1,294,344

These figures, which probably in another decade will read as nought, are already sufficiently imposing to justify the Argentine breeder in entertaining the most sanguine expectations as to the future.

The republic has in its favor several advantages to place it in the van of the mutton exporting trade. The first of these is the proximity it has to the European market, an advantage which should always serve it in good stead in competing with Australasia. Secondly, it has the special conditions of soil and climate for the production of mutton. Thirdly, the vast area of sheep country which it possesses and the exceeding facilities afforded to the breeder who can grow mutton at a cheaper rate than in any other pastoral country, and yet sell it at prices remunerative to himself. The country has therefore some claim to consider herself the future meat producer for overcrowded Europe.

Argentine mutton is steadily obtaining favor with the home buyer, and the following extracts, taken from a most interesting price table and review prepared by Messrs. W. Weddel & Co., will serve to show the present state of the trade. We find that during the by-past six years, Argentine mutton has fallen from 4½d. in 1886 down to 3½d. in 1891, a fall of 1d. per pound. Prime New Zealand mutton has fallen ¾d. per pound in the same period, viz., from 5d. to 4¼d. On the other hand, the importation of carcasses has been nearly trebled during this time, viz., from 1,187,547 in 1886 to 3,323,821 in 1891. The number of carcasses imported into the United Kingdom from the Argentine, which in 1883 barely passed 17,000, has now ascended to 1,073,525 in 1891. In addition to this there are over 100,000 carcasses exported to France from the River Plate. Messrs. Weddel & Co. make the following important remarks with respect to the quality of frozen mutton: "For several months past, the quotation for best River Plate mutton has exceeded by ¼d. per pound the price of New Zealand merino mutton. This overlapping of values leads to great confusion in the mind of consumers, who are now often unable to decide whether New Zealand or River Plate mutton is the better class of meat. There has been a distinct improvement in the character of the sheep imported from the River Plate during the year 1891, as compared with the two preceding years. This was only what was expected in a favorable season, the steps taken prior to 1889 with a view to improving the breed of many of the largest flocks in the country having naturally resulted in an all-round advance in respect of average weight per carcass and quality of mutton." They go on to say in conclusion: "Frozen mutton importations now represent from 15 to 20 per cent. of the total consumption of mutton in the United Kingdom. Having regard to the prejudice with which frozen mutton was viewed when first introduced into this country, the rapid development of the trade to its present important dimensions is worthy of being specially noted alike by producers in Australasia and South America, and by British farmers and consumers."

The question why Argentine mutton averages an inferior price to that of New Zealand has a three-fold explanation. In the first place, New Zealand possesses to-day a mutton-producing breed superior to that grown in the Plate. In the second, the New Zealander feeds his stock during the winter time with extra forage, while in the Argentine the sheep are allowed to graze upon the same bare pampa during the dead season. The result of this is that the New Zealander produces an even, well grown carcass, while there is sent home from the Plate one upon which a hasty covering of fat has been put during the spring months of the year. The difference between the two carcasses will readily be noted by any one who cares to pay a visit to Smithfield. Thirdly, the freezer in New Zealand freezes the mutton on account of the breeder, and in the Argentine the freezer buys from the breeder. The disadvantage of the latter system, so long as the breeder has no knowledge of the requirements of the market, is apparent. The New Zealand breeder selects his wethers with care, rejecting any which will give an inferior weight, or which are insufficiently fattened for the butcher. He remits them in small droves to the freezing establishments, and takes every care that they shall arrive in perfect order. The Argentine breeder, on the other hand, makes a contract with the representative of the freezer to sell a given number, and the latter binds himself to remove them within a certain date. The breeder endeavors to sell the greatest number possible, and it is easily com

* From "The History and Present State of the Sheep Breeding Industry in the Argentine Republic." By Herbert Gibson. Published at Buenos Ayres (1893), by Ravenscroft & Mills.—Ice and Refrigeration.

prehended that the buyer who selects from a farm carrying anything between 10,000 and 100,000 must perforce remove many wethers utterly unfit for the meat market. The freezer has probably extensive paddocks, but he cannot fatten up the great quantity of store stock which arrives together with the fat wethers; they must alike go to the butcher's knife, and so the Argentine mutton which comes to the European consumer is of inferior quality and more uneven than that exported from New Zealand.

Nevertheless, the conversion of the freezer into a mere commission agent is not the most felicitous solution of the frozen mutton question. There must exist some intelligent observation of the market to determine when to remit supply and when to withhold it. The breeder is not in a position to do this, and the individual effect of his own produce would not materially influence the price list either way. The freezer should assuredly be an interested party. The best system, therefore, and one already in some use in the Argentine, is to establish a scale of prices proportionate to the dead weight return of the sheep sent in by the breeder. This would alike stimulate the sheep raiser to turn out wethers of an even weight and quality, and secure to the freezer remunerative prices in the home market. It rests with the breeder to study the matter more closely, and have a care that no wether shall leave his run which does not reach the necessary weight and is not in the condition to fit it for the butcher's knife. In a previous chapter I have pointed out how the breeder should commence an inspection of his flocks immediately after shearing, and from time to time select those wethers he finds in sufficiently good order to remit to the freezer. He can go further. He can have a special paddock for the fattening of his wethers, and draft them from thence to the market. And he will find that in every step he takes toward improving the present stupid method of selling he will be gladly met half way by the freezer.

The mutton freezing process is one of great interest, and a visit to any of the principal establishments cannot fail to impress the visitor with the skillful organization and care of detail to be noted in every department, from the killing yards to the shipment of carcasses for Europe. Messrs. Sansinena's great killing place on the outskirts of the city of Buenos Ayres, and conveniently situated on the banks of the Riacho, a navigable river connected with the port and harbor of the city, has provided one or two illustrations for this chapter.

The sheep are introduced from the sale and receiving yards to large pens under roof. Here are slaughtered those destined for the local market, the number daily disposed of in this manner amounting to about 400. Those selected for the frozen trade, which are generally superior to those for local consumption, are driven up to the far end of the yard, where the preparations for slaughtering are more elaborate. The floor is concrete, and water is constantly being played over it. The sheep, whose death is instantaneously occasioned by the skilled thrust of the butcher's knife, is laid on a trestle or board covered wheelbarrow. Here the skin is partially removed, viz., at the legs and around the head. The body is then suspended on hooks and the skin entirely removed by another man, who also disembowels the carcass, takes off the head and trotters, and ties the forearms up with twine to give the body that neat trussed up appearance so necessary for the home markets. Up to 1,700 can be slaughtered for the freezing trade per diem, making with those destined for local consumption, a turn-over of 2,100 in all.

To follow the carcass first: It is conveyed to the scales and weighed, being sorted according to its weight. It is then hung up in a cooling room in order to be chilled, and left there until five o'clock in the afternoon. From thence it is hoisted by means of an ingenious elevator to the freezing chambers, where, robed in its clean linen cloth, it hangs for a period of not less than forty-eight hours in the dark, frost-covered vaults. Before it is placed in the freezing chamber it is weighed again; and still once more before shipment, making three different weighings in all.

The capacity of the freezing chambers amounts to 60,000 carcasses at one time.

The freezing is done by an eighty (nominal) horse power machine, the system being that of ammonia (De la Vergne). Another engine of the same capacity is at present being introduced.

The bowels and blood are run through drains, and by means of siphons the blood is run off and wasted. This is at present the only part of the animal which is not utilized by the company, but experiments are being made at the present time to find employment for this matter.

The intestines have all particles of grease removed from them, and are cleaned and sold to make sausage skins and guitar strings. The head, odd scraps of fat, paunch, and general offal are boiled down and refined, and the tallow is sold for exportation. The kidneys and tongues are sent home in a frozen state.

The kidney fat and fat robing of the entrails is put through an ingenious and remunerative process. While still hot, it is placed in large iron tanks, where a constant play of water soon renders it stiff. It is then broken up by machinery, rendered down and refined, until at last it comes out a fine yellow mass not unlike a puree of potatoes, and as pure and sweet as butter. It is removed to a warm room, placed in clean napkins, and subjected to hydraulic pressure. As grease becomes liquid at a temperature of 35° C., and tallow remains solid up to a temperature of 52° C., the temperature of the press room is kept at 40° C. The result of this is that the grease runs off the press in a liquid state, and the tallow remains still solid in the linen napkins. The grease, which has by this process been brought to an extreme of refinement, is put up in tins and sold for cooking purposes. It is termed "Oleo Palmatina," and the demand for it is greatly in excess of the supply. The tallow, which is of a superior quality to that obtained from the head and offal, is sold apart, generally for warm countries, where it is mixed with the commoner tallow to make candles. As this tallow will not melt at a lower temperature than say 45° C., it is in great demand in those countries where the climate is an extremely hot one. Its value is about 15 per cent. greater than that of ordinary refined tallow.

Thus every portion of the sheep is utilized with the exception of the blood. And it is probable that even for this there will shortly be found a profitable employment.

In the smaller freezing stores the curious visitor will see all manner of dainties—partridges, asparagus, fish, sucking pig, and what not. These little branch industries are by no means unimportant; and such items are not only largely employed in the commissariat of passenger ships, but also have a ready exit in Europe, where they arrive at a period when they are out of season in the old world.

Messrs. Drabble Brothers, John Nelson & Co., O'Connor & Co., and others, have also large establishments for freezing mutton, more or less upon the same system as Messrs. Sansinena.

There has recently been established in the vicinity of the town of Quilmes, about twenty miles from the city of Buenos Ayres, an extensive industry for canning and tinning both beef and mutton. This enterprise, entitled the Highland Scot Tin Canning Co. (Hercules machine), is prepared to exploit the stock of the Argentine upon an extensive scale. In addition to the elaboration of 1,000 and upward head of cattle per diem, the factory can turn over 2,000 head of sheep daily, freezing those carcasses most convenient for exportation in a frozen state, and canning the mutton of undersized and inferior breeds of bleaters. This industry is of great moment to the stockmaster, for it provides him with a market at unseasonable times, when a threatened drought or flood makes it necessary for him to dispose of a great number of his stock in little space of time.

The breeder has therefore a most promising outlook for the disposal of his surplus increase, the present demand of the combined frozen, live stock for importation, and local consumption markets amounting to about 4,500,000 head of sheep per annum, or say 6 per cent. of the total stock of muttons at present existing in the republic. If the breeder has a care to continue the improvement of the quality and condition of his butcher stock, he has every right to look forward to a bettering of prices and a wider demand for his wethers.

[FROM ICE AND REFRIGERATION.]

FISH FREEZING.

By D. W. DAVIS.

LAKE fish—white fish and trout—have been supplied to the markets of the country after the close of the fishing season by the fishermen on the Great Lakes since the year 1868. Before that time, when navigation closed in the fall with the coming of ice in the straits and in the harbors, the supply of fish pretty generally ceased; but in 1868 a few tons of white fish were frozen artificially, and since then the business has steadily increased from year to year, the estimated quantity handled in 1893 being 3,000 tons.

In freezing fish the stock should be perfectly fresh and should be frozen quickly and at a low temperature, as freezing does not improve the quality of the stock, but simply prevents its decay. The time occupied in freezing in "The Davis Freezing Pans" is generally about six hours, when the pans are properly packed.

These freezing pans are made of No. 24 Junietta galvanized iron, twenty-eight inches long, fourteen inches wide and three inches deep, fitted with a cover two and a half inches deep. The corners of the cover and pan should be turned, riveted and soldered, so as to be water tight.

The fish are packed in the pans, backs up, so that when the cover is put on it will be in contact with the fish. This is very necessary, for the fish must be in contact with the iron and the freezing mixture in contact with the metal to produce rapid freezing.

After the fish are placed in the pans, these are packed in nonconducting boxes or bins between alternate layers of fine ice and salt, where they remain until the fish are frozen solid. About thirty pounds of Diamond salt to 100 pounds of ice is a good proportion. It should be well mixed, and should be put into the bins in layers about four inches thick between the two layers of pans. This produces a temperature almost as low as zero, F., on the outside surface of the pans, and the fish being in contact with the inside of the pan, it will be readily understood that the fish will freeze very quickly. After the fish are frozen they are removed from the pans to the storage room.

Naturally at this low temperature, the fish being moist, they freeze solidly together and also to the pan. To remove them, pour cold water on the pan, which will draw the frost sufficiently from the iron to allow them to be removed without breaking a scale.

After the fish are taken from the freezing pans, it is necessary to put them in the cold storage room as soon as possible, but before they are stored away they should be dipped in ice water for a moment, which will cover them with a thin film of ice, about a thirty-second of an inch in thickness. It makes no difference how low the temperature is, there is a certain amount of evaporation going on all the time, and by coating the fish in this way it prevents the evaporation of the juices of the fish just so long as the coating lasts. Fish frozen and treated in this manner and kept in a temperature of 12° below the freezing point of water, can be perfectly preserved for four to five months in a perfect condition. Fish not treated in this manner, in a very short time get discolored and lose their flavor.

The temperature of the storage room should be about 20°, or 12° below the freezing point. The cakes of fish should be put in boxes, in which case the chances for evaporation are very much reduced, and the fish keep better.

It is best to always freeze fish just as soon as it is possible to get them from the water, since the fresher they are, the finer the flavor, and this flavor does not deteriorate in freezing. It is impossible to put a coating of ice on the fish, after they are taken out of the freezing pans, of sufficient thickness to last for a length of time more than stated, owing to the great evaporation in the storage rooms.

Fish dry out about two and a half pounds to the hundred in freezing, but gain five pounds in a hundred by the coating process.

It is not necessary to dress fish before freezing. The less fish are handled the firmer they will remain. Fish in the natural state handle and look better than dressed stock.

The above description is freezing by what is known as the dry process, and is used by all dealers in the United States and Canada, all patents having expired.

A process of freezing fish in ice, patented in 1880, by the author, may be deemed worthy of notice. By it the fish are handled and go through the same process of freezing as above described, except that they are packed in fine pulverized ice in the pans before being frozen, and when taken out of the pans the fish are so solidly embedded and frozen therein that they are part of the crystallized water; in fact, they are hermetically sealed and incased in a crystal jacket. Fish thus frozen and preserved have all the appearance of stock just taken from the water, as everything belonging to the fish is in the same natural condition that it was when alive in its native element, except that animation is suspended by the packing and refrigerating process; and so long as they are kept in this state there will be no change in their color, texture or taste, for they are hermetically sealed in ice; there is no chance for evaporation to take place, and the fish retain all their flavor and juices, and can be kept for ages in a fresh and perfect state.

"At the beginning of the present century a Siberian hunter discovered an entire mammoth frozen in a mass of ice and another has since been found, both of which were so perfectly preserved that microscopic examinations of sections of some of the tissues were able to be made. It was found in Siberia, and the bones were set up and are now in the museum at St. Petersburg," says the Encyclopædia Britannica, Vol. VIII., page 125, ninth edition, under the heading of "Fossil Elephants."

"In 1800 a Russian naturalist, Gabriel Sarytschen, discovered the body of a mammoth wrapped up in a shroud of ice, and the body was in a complete state of preservation, for the permanent contact of the ice had kept out the air, and prevented decomposition; the waters had disengaged the mammoth, which had been imprisoned in ice for thousands of years," says "The World Before the Deluge," by Louis Figuir.

The inference from the quotations is obvious.

HOW RUBBER BULBS ARE MADE.

IT is commonly supposed by the uninitiated that the "bead," or raised line, that encircles a bulb shows the joining of the pieces of which it is made. The fact, however, is that the pieces or original parts of the bulb are invariably joined at right angles to the bead line. Long bulbs, such as syringes and atomizers, are made of two pieces; round bulbs, as pumps and balls, are made of three pieces. New and unique styles that call for variation from the established modes are daily encountered. A competent pattern maker, however, will find little difficulty, as a general thing, in so joining the parts as to secure the best results, both in vulcanizing, where the even swelling of the article must be considered, and in wear and tear, where the seams must run so as to be protected as much as possible by the general contour of the bulb.

After the pattern maker has decided by measurement and experiment upon the shape and size of the parts which go to form the bulb, zinc or galvanized iron patterns are made and given into the hands of the cutters. Mixed sheets of the required thickness being spread and afterward cut into convenient sides or squares, the bulb making begins. Each piece cut must have distinctly skived edges. Considerable care is necessary in this, as the strength of the seam depends upon the smooth fitting of the edges. The three parts for hollow balls may, however, be cut with a die. The pieces when cut are arranged in large books with leaves of smooth cloth. If the bulb has a neck, small pegs of iron are first prepared by being cemented and wound with strips of rubber as a nucleus for the neck. The two or three parts of the bulb are then brushed with cement the whole length of the skived edge, after which they are thoroughly heated.

When thoroughly warmed and softened, the bulb maker, taking a prepared peg, places the neck of one piece on one side of the rubber core, and another neck piece on the opposite side, then presses them firmly together, and rolling the whole tube-shaped piece between thumb and forefinger, has finished the neck of the bulb. The next process is that of knitting the edges which form the seam. Holding the finished neck toward him in his left hand, with the thumb and forefinger of the right he pinches the edges firmly together for nearly the whole distance round. The shape is now not unlike that of a "long clam." Into the side aperture, which is left open, is poured a little water or liquid ammonia. The opening is then made still smaller, and as a final touch the maker puts his lips to the orifice, and puffing out his cheeks till they look like miniature balloons, blows full and hard into the inside of the bulb. The softened rubber under this sudden pressure expands, the flattened shape is lost in a fuller and more rounded outline, while the operator, with a quick nip of the teeth, closes the opening, the imprisoned air and water holding the sides apart in symmetrical corpulency. There are those who can never learn the knack of blowing up a bulb with the mouth, but are obliged to use a bulb to inject the air.

After the makers have done with the now partly made bulb, it is passed to the trimmers, who, armed with scissors with curved blades, carefully circle the seams, cutting away all unevenness, till the whole exterior is smooth and ready for the mould. In front of the trimmers are a number of shallow pans partly filled with chalk. Into these the bulbs are laid. A small dumb waiter takes them down to the mould room and returns the empty pans. The bulbs on leaving the chalk pans are deposited in a small cylindrical box which, turning a few times, powders them so effectually that the rubber cannot adhere to the inside of the mould. An experienced mould worker now taking one-half of a mould in his left hand, with his right gently forces the bulb into it, capping it with the second half. If the pattern maker has done his part faithfully, each will just fit its mould. If not, they will come out of the vulcanizer wrinkled, showing that it was too large; or, if glazed and imperfect, that it was too small.

A flat iron ring or clamp holds the two sections of the mould together when in the vulcanizer. This is tightened by iron wedges which are driven between the mould ends and the clamp. The moulds after being

keyed are piled on cars that run upon small tracks into the vulcanizers, and are cured by steam heat. When the curing process is completed the vulcanizers are opened, and the cars, by a short extension of the track, are run under a simple shower bath, which quickly cools them. They are then unkeyed, the moulds twisted open and the bulbs taken out. If the work be well done, the swelling of the liquid within its rubber prison has exerted so intense a force that every line and letter within the mould is reproduced upon the outside of the bulb, while the sulphur combining with the heat has sealed the copies with its magic spell.

The iron peg in the neck is next loosened by means of a blunt awl, and slipped out, leaving the bulb perfect in shape. In the mould room are large car-like boxes into which the bulbs are thrown. A box being full, it is trundled away to the cylinder room, where it undergoes a thorough scouring and polishing in huge slowly revolving cylinders.

When taken out of the cylinders, the dirty yellow color which the bulb bore on leaving the mould has wholly disappeared. It now looks smooth, white, and finished. The neck being cut off the required length by a small adjustable cutter—devised expressly for the purpose—the bulb is ready for market, or for the various fittings which accompany it as adjuncts to the syringe, atomizer, or other bulb. Where a smooth, clear-cut hole is needed in any part of the bulb, except the neck, it is cut by a swiftly revolving punch. The neck hole is left by the iron peg as already described.

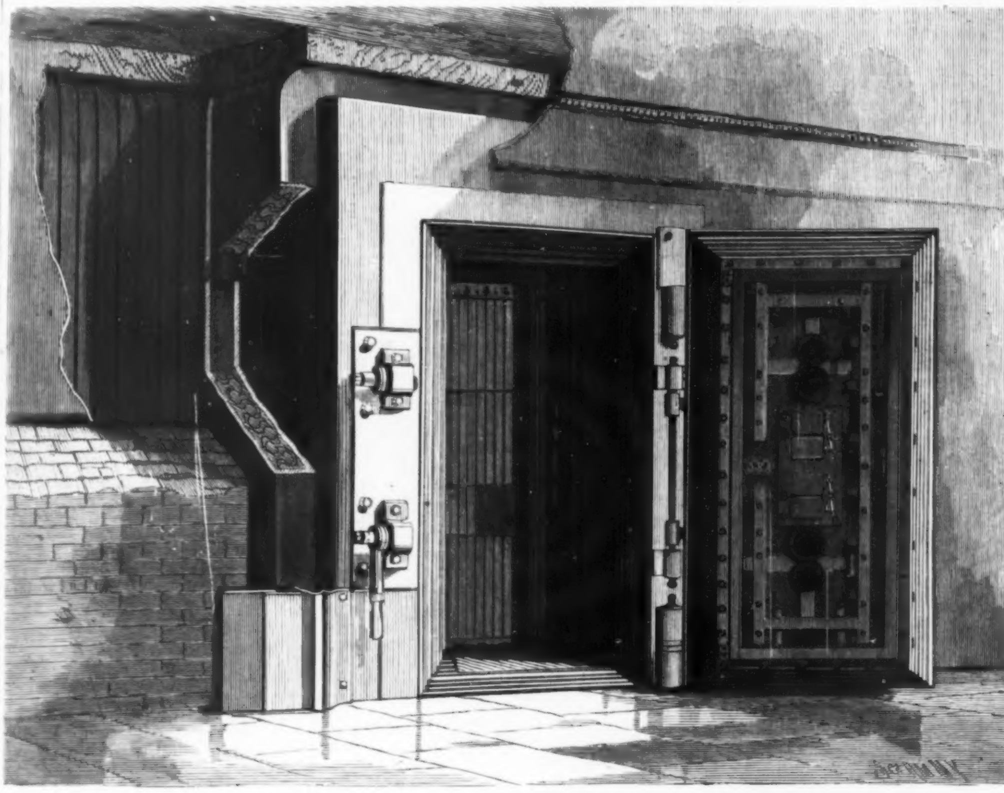
A good illustration of the power of the imprisoned steam within the bulb may be obtained by knocking a clamp off a mould before it has been treated to the shower bath. The two hemispheres of iron will fly apart as if by magic, the bulb swells to treble its normal size, and explodes with a loud report. The mould workers are sometimes badly burned by hot water which bursting bulbs scatter in all directions.

A well made bulb, one that has a good, energetic spring, that has just the right smoothness of outline, that is not scarred by imperfections in the mould, and that has the whiteness of a healthy cure, is an object that always wins the respectful admiration of rubber men. Toys, balls and hollow goods generally are all made in the same manner as bulbs.—India Rubber World.

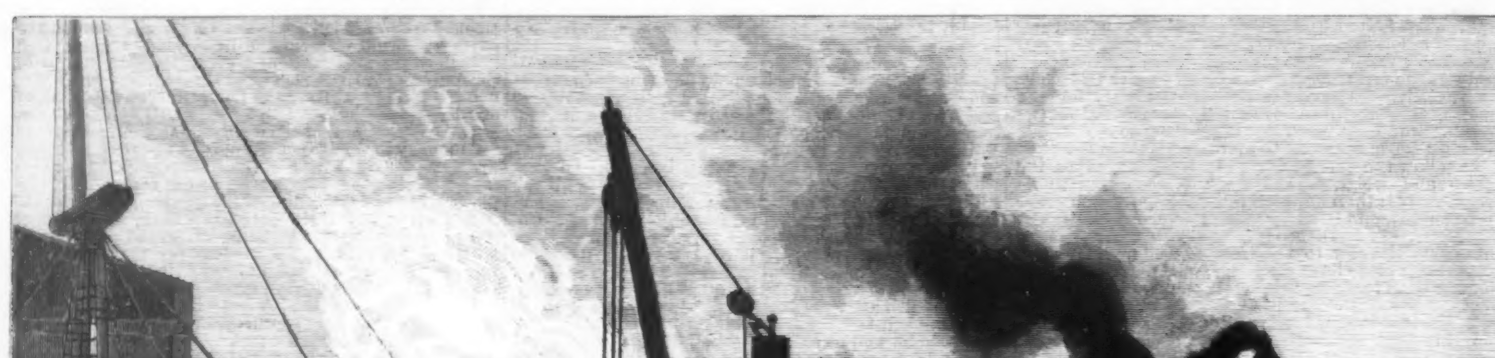
THE MANUFACTURE OF BURGLAR PROOF VAULTS.

THE manufacture of burglar proof vaults has, like many other industries, emerged from the stone into the steel age. In earlier times the stone and brick walled vault was considered safe. To-day the improved appliances of the burglar can only be resisted by steel. In the present issue we illustrate some of the processes of the manufacture of burglar proof vaults, of which several very fine examples have recently been erected in this city and Boston. The walls of the vault proper are built of composite plates formed of alternate layers of soft steel or iron and of the hardest steel. In the cut, Fig. 2, the section of a plate is shown. This is a five-ply plate, with two steel layers and three iron ones. While various dimensions may be chosen, these plates are generally used of one-half inch thickness, except the outside one, which is one inch thick. The walls are built up of such plates, laid so as to break joints, and screwed together with flat-headed top bolts. Even the bolts are made of the same composite metal, twisted around. The small cut shows one of these bolts with the side cut away so as to show the steel embedded in the iron and twisted helix fashion.

When the plates are received their edges are planed and they are drilled and tapped for the screw bolts. Each bolt goes through one plate, its head entering a countersunk hole and lying flush with the plate and screwing into a tapped hole in the next plate. The drilling we show as executed by the Moffet steam drill. A small rotary steam engine is mounted over the drill and steam is conveyed to it by a hose. As it turns it



SAFE DOOR AND PROTECTIVE CAGE OF RAILS.



THE BANK VAULT INDUSTRY—HARDENING THE PLATES IN SALT WATER.

works the drill by gearing. In Fig. 3 is shown a workman drilling one of the plates. The outside plate has blind holes only, none going through it, and these holes are all tapped. In the building the first layer of plates is bolted to it, the next layer to them, and so on until any desired thickness is obtained.

The entire vault is built up in the factory, every plate having its own place. Next the whole is dismantled and the plates are hardened by heating to redness and immersion in water, of which process we give illustrations.

This often entails warping, and accordingly many of the plates have to be rolled cold to straighten them, and some have to be polished off to a flat surface with an emery polisher, shown in Fig. 4. The workman cuts down any high portions of the plate until it is adapted to bed well against its neighbor. The edges have often to be ground off, the emery wheel buffer shown in Fig. 6 being employed.

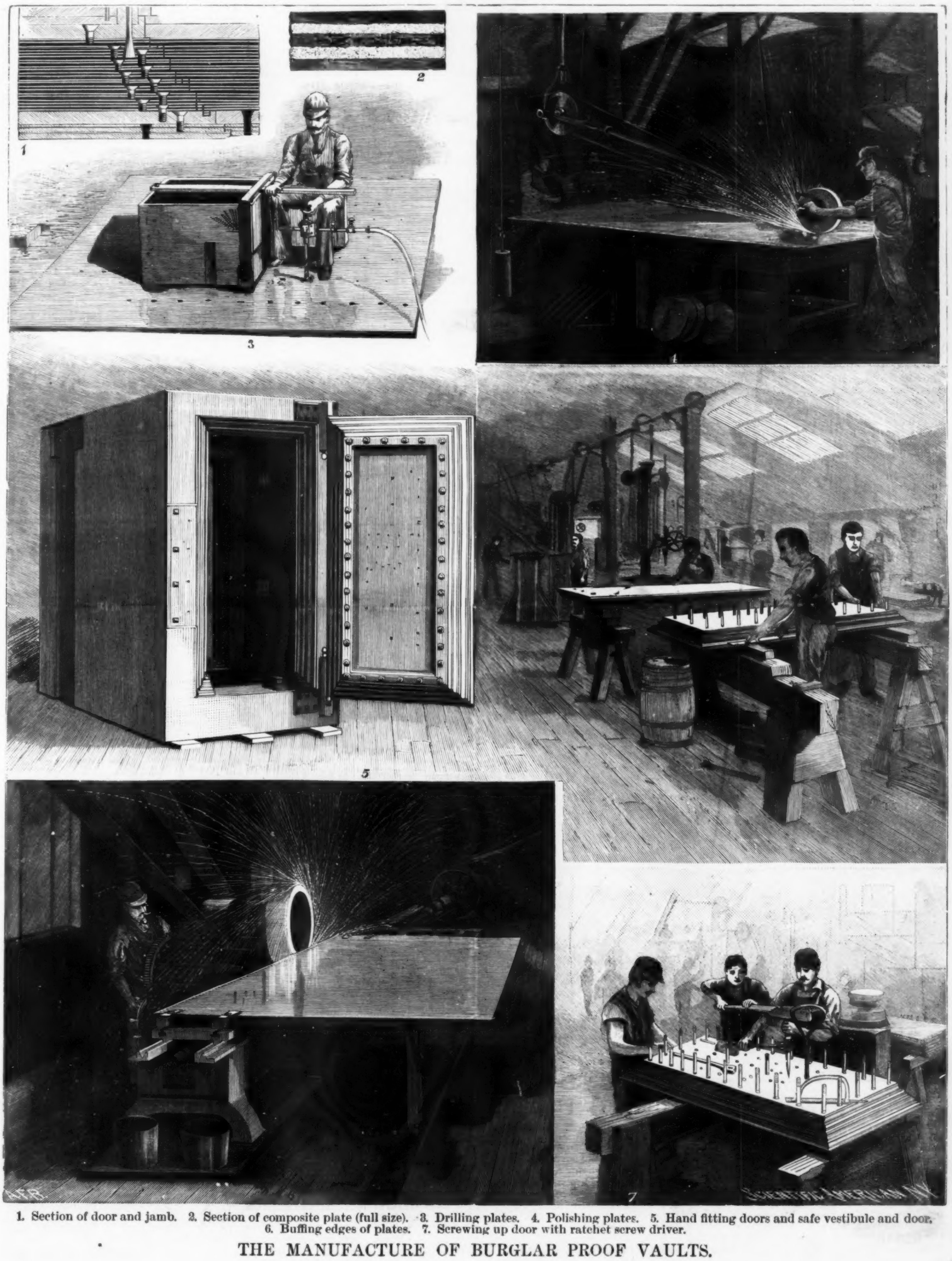
The doors are built up in exactly the same manner. Their joints or edges are of very complicated cross section to prevent wedging, as shown in Fig. 1. Here three tongues are shown entering grooves in the jamb to afford additional protection against yielding to lateral wedging. These joints have to be constructed with great exactness, and the surfaces are all hand filed and polished. The fit alone makes them almost air tight, and list packing is also employed to insure a fit.

In Fig. 5 is shown one of the great doors mounted in its vestibule; while the process of hand filing the edges is also shown.

Doors fitted as described make it impossible for the burglar to introduce gas, or a liquid, or finely divided explosive for blowing up the safe.

The inner face of the door has much of the machinery of the locks exposed. Over it is bolted a cover of heavy plate glass. In the cuts Fig. 5 and 7 the bolts for this cover are shown projecting around the edges. In the cut on opposite page the interior of a finished door is shown.

As a single door may weigh from four to six tons, ball-bearing hinges are employed to enable a man to



1. Section of door and jamb. 2. Section of composite plate (full size). 3. Drilling plates. 4. Polishing plates. 5. Hand fitting doors and safe vestibule and door. 6. Buffing edges of plates. 7. Screwing up door with ratchet screw driver.

THE MANUFACTURE OF BURGLAR PROOF VAULTS.

close and open it. Time locks are used, which are set at night to run a given number of hours. Until the time assigned has expired, it is impossible to open the safe.

These vaults are often very large. In this city the National Safe Deposit Company has one in the Mutual Insurance building which has an area of fifteen feet six inches by forty-three feet ten inches, and which is nine feet high. Nearly 400 tons of steel are used in its construction. It has two entrances, the doors of which are controlled as regards opening by three clocks on each one. All the clocks are kept running, and any one is sufficient to release the time locks on its own door. Thus if five clocks out of the six were to break down, the locks on one of the doors would still be released when the appointed time came.

A further protection is sometimes given to the vaults by a species of cage made of special section railroad iron, which is built up around the steel structure. Our cut on page 15822 shows this element in its relation to the rest of the structure. The rails are closely nested, and when in place are bedded in or run with Portland cement.

The general arrangement of the vaults involves their exposure on all sides to the watchman's patrol. No part must be against a wall, as this would give burglars a chance to penetrate through the wall and work in concealment upon the sides of the vault. But even if a burglar were given free scope, it is doubtful if he could, within the few hours open to his operations, do much in the way of perforating the compound plates. The hard steel is almost undrillable, and if sledging or ramming were resorted to, while the hard metal might crack, it would remain so firmly bedded between the layers of soft steel that it would still resist the drill. The interior of these large vaults may be fitted up in any desired way. They may contain a quantity of smaller safes subdivided in any desired way. Electric light may be used for lighting and as an adjunct to safety. A steam pipe may be arranged over the doors outside the vault, by means of which a volume of steam may be discharged in a case of a riot which would prevent any one from being able to even approach the vault. All these appliances may be seen in the National Safe Deposit Company's vault already alluded to, and which was constructed by J. B. & J. M. Cornell, of this city. In it are embodied all the features of construction described here.

One of the illustrations accompanying this article shows a somewhat curious operation incidental to the manufacture of steel and iron vaults, the hardening of the plates, as employed at the works of J. B. & J. M. Cornell, in this city, and consists in dipping the hot plates into salt water. Advantage is taken of the water front held by the firm in utilizing in situ the salt water of the Hudson River for the purpose, a brine dip being considered superior to one of fresh water. There is unquestionably a difference between the two. The addition of a soluble salt to water raises its boiling point, and to some extent improves its hardening power.

Special heating furnaces are built in the open air upon the margin of the river, and plates of steel heated in them are dipped into the river to harden. Except for docking and shipping purposes, it is about the only technical use made of the river proper.

The work on the plates, including the drilling and tapping of holes, shaping the edges, etc., has to be done while they are soft. The entire vault is built up of the unhardened plates, each one having its exact place assigned it. The vault is next taken down, piece by piece, and the pieces are hardened. It is this operation which we illustrate. On the edge of the dock on the North River front, near the foot of Twenty-seventh Street, in this city, reheating furnaces have been built adapted for heating the metal to redness. The plates are put in and are brought to a good red heat. They are then removed from the furnaces and as quickly as possible dipped edgewise into the river. In this way they get a salt water hardening. They are then to be rolled cold for the purpose of straightening them. Previous to the heating the blind holes in the one inch plate are stopped with clay to prevent cinders from getting in. After rolling, flattening, and cleaning the plates are ready for shipping and erection.

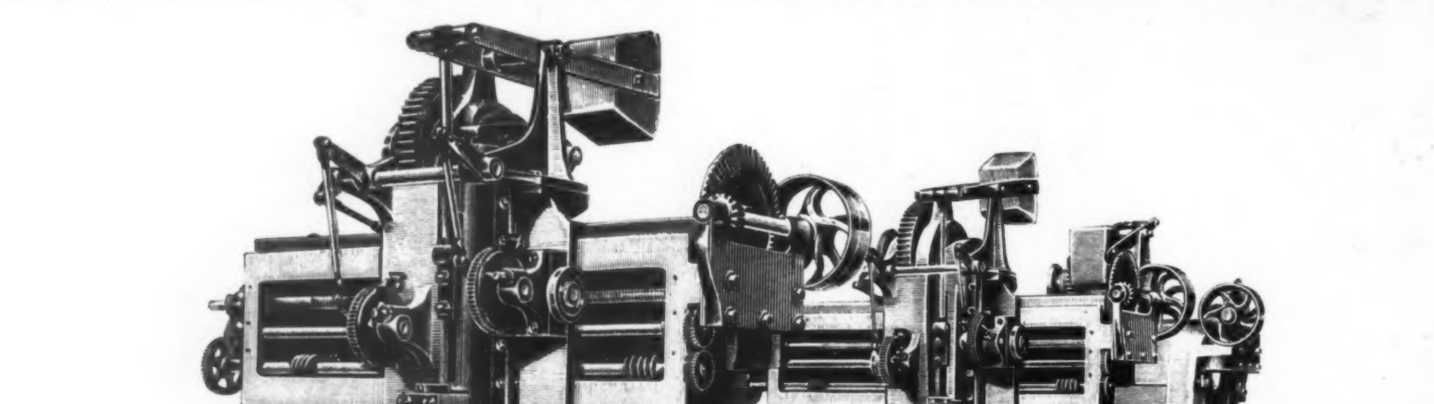
COMPOSITE STEEL BOLT.

LOCOMOTIVE FRAME PLATE SLOTTING MACHINE.

DURING a recent visit to the Vulcan Foundry Company, Newton-le-Willows, near Manchester, says the Engineer, London, we noticed, among new plant that had been put down in connection with the extension of its locomotive works, a specially designed frame plate slotting machine, made by Messrs. Craven Brothers, of Manchester, containing several new features, a brief description of which will be interesting. The accompanying illustration shows the general arrangement of the machine, which has a massive bed 36 feet long, admitting plates 5 feet wide, and there are three heads, each with a ram having an adjustable stroke up to 15 inches deep. The heads, which are all identical in construction—so that the following description applies to each—can be worked all together or stopped and started separately, and the self-acting feed motions are self-contained on each carriage, thus enabling each head to work independently, or the three heads can be operated all together. The self-acting feed motions are timed to feed before the cutting tool starts at the top of stroke, and the feed is regulated for fine or deep cuts, this being effected by a circular plate alongside the catch wheels. This plate is arranged with part of its circumference the full diameter to the top of the catch wheel teeth, and the outer part of its circumference to the same diameter as the bottom of the teeth, and the plate is regulated in position by a small worm wheel motion to allow the feed catch to ride on the full diameter or on the smaller diameter, so as to shield or expose the teeth in the catch wheel to the action of the catch.

The plate can thus be regulated to allow the catch to take one tooth or many without altering the position of the studs in the levers. Two self-acting feed motions are provided on each head, one for the longitudinal, and the other for cross traverse motions of the cutting tool. When it is required to slot the horns of locomotive framing taper, there is an arrangement by which the longitudinal and cross traverse motions are in gear at the same time, and by means of change wheels various tapers can be slotted self-acting, the cutting rams being thus enabled to slot parallel or at right angles to the bed or taper. The cutting rams are worked first by a shaft the full length of the bed, having a key groove its full length, with a large three-speeded cone pulley at the driving end, and three broad pulleys, one for each head. These pulleys have a long boss working in a collar bearing on each head, and moving with the head; the boss is fitted with a long steel key working in the key groove in the long shaft, and each of the three broad pulleys drives a pair of fast and loose pulleys on the heads, while a strap lever arrangement is provided at the front side of the machine to enable the workmen to transfer the driving belts to the fast or loose pulley to start or stop each head.

The pulleys on the head drive a pinion working into a large bevel wheel upon a shaft; this shaft has a pinion with a steel key in the boss working in the key groove in the shaft, and the pinion works in a bearing on the carriage, and drives a large spur wheel on a shaft with a forged steel disk at one end. This shaft runs in two bearings, the driving wheel being between the two, the disk being supported in a bearing at its outer diameter and made with a planed slot across it, and fitted with a strong stud or crank pin, which is altered in its position on the disk by a screw to regulate the length of the stroke, and when adjusted is secured to the disk by a large nut. The stud or crank pin is provided with a hardened steel block which works into a hardened steel vibrating link on a fixed stud on the carriage at one end, and a connecting rod at the other connected to the cutting ram, which is raised at a quick speed in the up stroke and slower at a uniform speed in the cutting or down stroke, and the position of the ram is variable to suit the height or thickness of the work to be slotted. The bottom end of the ram is provided with a tool holder which can be rotated by a worm wheel motion for slotting curves, and the ram is balanced by a weight and levers to facilitate the quick return motion and relieve the strain on the crank disk and link.



LOCOMOTIVE FRAME PLATE SLOTTING MACHINE.

SINGLE CYLINDER SIMPLEX GAS MOTOR OF 320 HORSE POWER.

THE use of gas motors is daily increasing by reason of their simplicity of installation, the ease with which they are run and the cheapness of their operation. Since 1884, the epoch at which Messrs. Delamare, Deboutteville and Malandin applied their first motor operated with poor gas, every year has marked a new progress, and the most diverse industries have been seen successively employing "Simplex" motors of from 25 to 100 h. p., and with a single cylinder; but it remained to make a considerable of a stride from a technical standpoint, and to pass from 100 to 250 h. p. Such dimensions were reached that the questions of expansion, unequal heating of the walls, cooling of the piston, ignition, etc., presented exceptional difficulties that long experience alone could aid in surmounting. Now that this important progress has just been realized in the most happy manner, the above named house is aiming still higher, and proposing to reach a 500 h. p., with the certainty of seeing its expectations borne out, as they were in the case of the 250 h. p. motor.

This result does honor both to the inventors and to the works of Mattu & Co., the grantees of the Simplex patents, who have not hesitated to undertake the construction of a motor capable of developing a power that has not hitherto been reached with the use of poor gas. It is but just to include in these eulogiums Mr. Abel Leblanc, the great miller of Pantin, who has introduced into his recently reconstructed

mills all the improvements that have been made in modern milling and mechanics. We are going to describe the installation of the motive power realized therein by means of poor gas.

(1.) Production of the Gas.—The gas generating apparatus of the Buire-Lencauchez system, which likewise are constructed by Mattu & Co., consist of two generators so coupled that they are capable of operating in unison during the regular running or separately during the time devoted to the cleaning of the furnaces. The motor runs day and night without stopping, since the operation of the mill cannot be interrupted except in case of actual necessity. With the combination adopted, one of the gas generators furnishes the quantity of gas necessary during the momentary stoppage of the second.

The isolation of the gas generator that has to be freed from its ashes is easily obtained by means of a double cylinder provided with a water cock, which, being opened, allows the water to rise in one of the sides to interrupt the communication of this generator with the gas reservoir.

A blower furnishes each generator with the quantity of air necessary to it, according to the opening of a special automatic register.

Upon making its exit from the generators, the gas, which escapes from the cylinder, traverses a series of pipes which cool it partially before it enters the washer, which consists of a simple coke column through which the gas filters in order to become cool and deposit its tar. A current of water falls from the top of the washer upon the coke in order to facilitate this operation.

Upon making its exit from the washer the gas enters a dry coke purifier and thence flows to the gasometer. An improvement of great importance in practice has been introduced into this installation, and this consists in the use of a new combination that permits of the radical suppression of the rubber pockets.

(2.) Motive Power.—The motor is of the well known Simplex type, but completely transformed by the inventors, both in the details of the distribution and the internal arrangements. It, therefore, but remotely resembles the 100 h. p. type previously set up.

In order to allow our readers to appreciate the dimensions of such an engine as compared with those hitherto constructed, it will suffice to say that with the largest cylinders of gas motors it is possible to produce but from 80 to 100 h. p. with the city gas, while under the same conditions the new motor would develop 450 indicated h. p. With poor gas at the time of the experiments, it gave 320 indicated h. p., and now it is running under a charge of more than 280 h. p., corresponding to more than 220 h. p. at the brake.

As shown in the accompanying engraving, this motor is provided with but one cylinder, and it was in the establishment of this single cylinder type that resided the difficulty. The internal diameter of this single cylinder is 35 inches. The stroke of the piston is 3·28 feet, and the velocity is 100 revolutions per minute.

This motor, which, in anticipation of the use of impure gas, had been very broadly calculated, has fulfilled every expectation, and, in this respect, is indeed the type of 250 h. p. at the brake.

From the view-point of execution, all the improvements responding to the necessities of a run without stoppage have been introduced.

When such powers are attained, the very complex questions of heating and expansion render the establishment of the internal parts very delicate. The thicknesses of metal in the cylinder, the water jackets, the inlet and outlet valves and the piston itself must be so arranged that the metal shall everywhere remain at a certain temperature calculated according to the place and the function of the part that it constitutes. Were not special precautions taken in this direction, certain points would be superheated to an exaggerated degree, while others would be entirely cold. A special system of water piping has been established to this effect, and having been regulated once for all, assures to each part of the motor the temperature adapted to it.

The conditions peculiar to the mill run by this motor require an operation day and night without stoppage. With a view to the realizing of such an obligation, an igniting arrangement has been devised that meets every emergency. The lubrication of the various parts likewise has been arranged with a view to a continuous running.

(3.) Consumption.—The fuel used is close-burning coal of the Anzin mines. Since a trial with the brake of so large a motor was almost impossible in the room in which it is situated and would have necessitated the stoppage of the mill for some days, one had to be content with a trial in industrial running. This was done with the greatest care and during a long period of operation. As the charge of the mill remained absolutely constant, and the operation took place without interruption day and night, account had to be taken of no variation in resistance, and no deduction had to be made for times of stoppage. These again are chances of error that are avoided.

A first trial was made in the month of February and carried out in the following way: Two trucks of 22,000 lb. each were set apart and after the gas generators had been filled to the top with old coal, the time of starting was carefully noted. The mill having been charged according to an invariable determinate production, curves were taken on the motive cylinder during the entire duration of the trials in order to determine the stress behind the piston and the corresponding power.

After the two trucks were exhausted, the time was noted at the very instant at which the two gas generators were filled to the brim for the last time, and it was found that the running had lasted 194 hours under charge.

The planimetric curves showed an indicated work greater than 280 h. p., which corresponds to more than 220 h. p. at the brake.

The gross consumption of coal, no deduction made of the ashes, although this is generally done, was

$$\frac{44{,}000 \text{ lb.}}{194 \text{ h.} \times 280 \text{ h. p.}} = 0{\cdot}8 \text{ lb. in indicated h. p., and}$$

$$\frac{44{,}000 \text{ lb.}}{194 \text{ h.} \times 220 \text{ h. p.}} = 1{\cdot}03 \text{ lb. in h. p. at the brake.}$$

The consumption of water noted during these trials was 6·1 quarts per hour for the cooling of the motor and less than 3 for the washer and the two gas generators together, say a total of less than 40 per horse hour at the brake, while the best condensing engines do not consume less than from 50 to 60 gallons per horse hour.

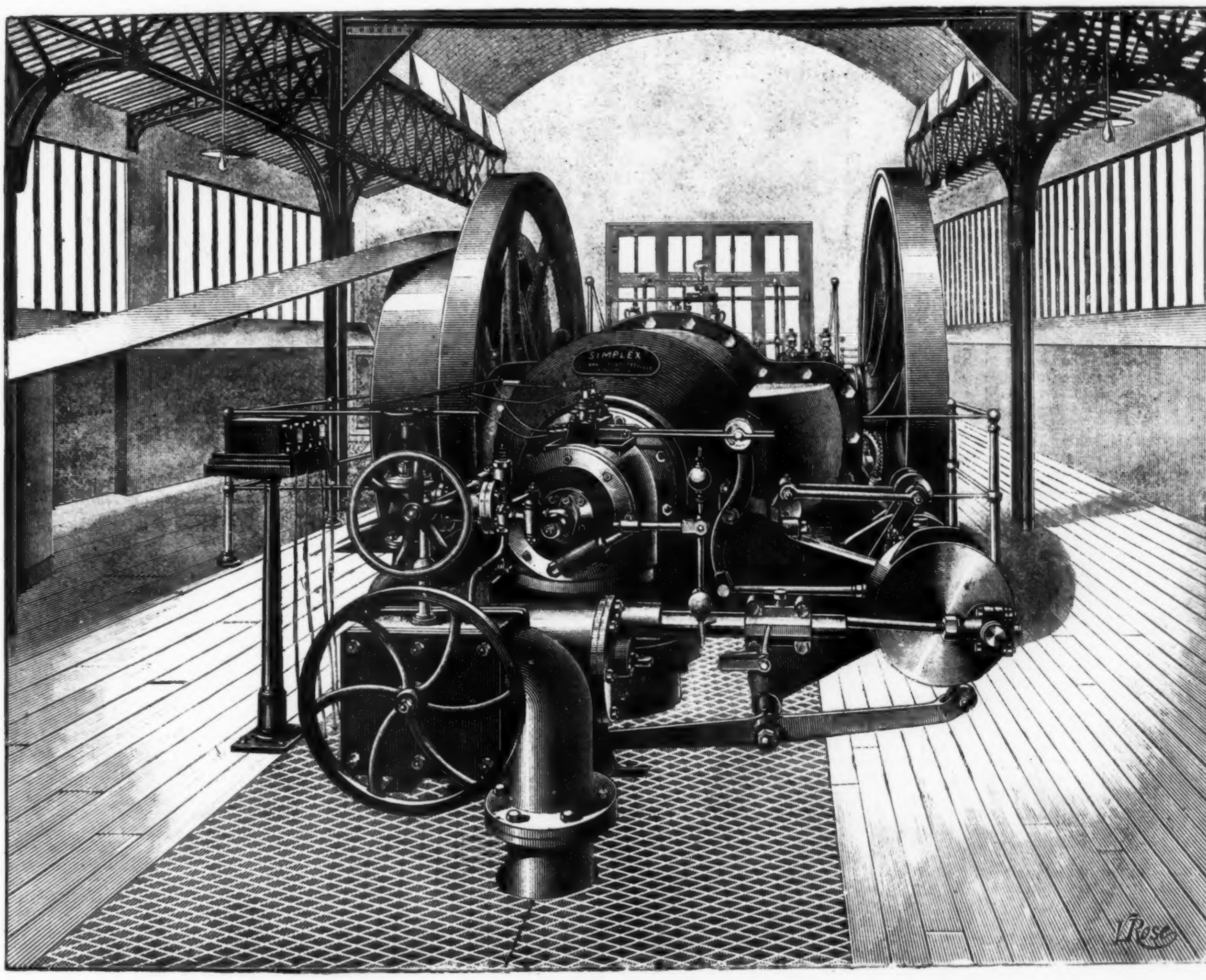
Such results, from the double standpoint of the consumption of coal and water, need no comment, for there are no steam engines, however improved they may be, that can approach such figures, not only during trials with the brake, but still less during ordinary running.

Three months afterward (in May last), new trials were made under the same conditions and gave results that were sensibly identical, and even better. There is still another advantage to be considered, for in a steam boiler scales are necessarily produced that increase the consumption after a certain length of running, while the consumption of gas generators remains the same for years.

(4.) Mills.—It will not be superfluous to say a few words as to the mills of Pantin, the complete reconstruction of which dates back to 1890, and which, from an economical as well as an industrial standpoint, are in an exceptional situation. The site selected for their establishment, at the gates of Paris, is a most fortunate one. They are situated opposite the Ourcq Canal and upon the railway line of the East, which permit grain to reach them under the easiest of conditions.

Upon its arrival, the grain, brought by barges or by cars, is introduced mechanically into a large silo structure of the most recent type, which, in addition to apparatus for scouring grain, contains a series of automatic carriers that lead the grain to the mill properly so called, according to the needs of the manufacture. These carriers, moreover, are so combined as to be able to change the grain from one silo to another, in order to prevent the heating of it. Upon coming from the silos, the grain, which traverses the courtyard upon an endless belt, goes, as we have said, to the principal mill, where it is scoured, brushed and freed from gravel. Crushers arranged in two parallel rows upon the ground floor afterward crush the grain in order to convert it first into grits, and then into flour, which are bolted in succession in the upper stories. There a series of improved bolting mills separate the flours according to their quality, as well as the brans; after which they are sent one after another to a third building that serves as a storehouse. A series of special chutes assures the mechanical carriage of these products.

The last-mentioned building contains the apparatus designed for bagging the flour and bran. In front of it there is a platform, up alongside of which the



THREE HUNDRED AND TWENTY HORSE POWER GAS MOTOR—SINGLE CYLINDER.

wagons come that are to carry away the products for Parisian consumption. As may be seen, everything is done mechanically in this mill, and this is a great advantage as regards quickness of production and saving in manual labor, which latter, reduced to a minimum, necessitates simply a few men for the general surveillance of the apparatus, the bagging, and the delivery of the flour.

The lighting is assured by three hundred electric lamps, the dynamos that supply which are actuated directly by the motor. A series of pumps furnishes the water necessary for the scouring of the grain and for the motive power. Upon the whole, all the measures taken are most remarkable.

(5.) General Considerations.—The economical conditions of this application are such that they merit fixing the attention of engineers, electricians, and manufacturers. The best steam engines for powers exceeding thousands of horses succeed only with difficulty in realizing a consumption less than 1½ lb. per indicated h. p., while the gas motor easily falls below ¾ lb. in a regular operation and with powers of less than 300 horse.

Now, the rendering of the steam engine may be considered as having reached its maximum after an existence of a century, thanks to the persevering study of numerous engineers. It is scarcely probable that such results can be sensibly improved upon to-day. On the contrary, although the gas motor is only in its infancy, since it dates from hardly a dozen years, it has, as regards consumption, nearly reached the maximum of its practical rendering. There is here a fact that seems extraordinary at first sight, but when we study things closely, we remark: 1, that the quantity of poor gas produced per pound of coal is from 70 to 88 cubic feet, without a possibility of these figures being exceeded; 2, that the calorific power of this gas varies but little, since it oscillates between 35 and 45 calories per cubic foot, whatever be the quality of the coal employed;* 3, that an explosive mixture produces its maximum effect only with an invariable proportion of gas. Too much or too little gas gives a feebler or even no motive power. Now this maximum is reached when the quantity of poor gas varies between 75 and 90 cubic feet per horse hour at the brake.

In the present state of the question, it seems difficult, therefore, to arrive at a notable improvement in the consumption; but the result is already such as to allow us to get a glimpse of a brilliant future for installations of poor gas.

There is, however, another side to the problem that leaves the field free to all initiatives and all studies; we refer to the quality of the coal employed.

At the beginning, and during the first eight years, the exclusive use of anthracite was a necessity, because it was possible for the gas generators to operate only with this fuel. Such inconvenience was obviated when, thanks to the Buire-Lencauchez apparatus, it became possible to employ close burning coal from various sources, costing nearly half less than anthracite; but, in order to reach such a result, it was necessary that the motors should be capable of using gas of from 1,200 to 1,400 calories, since the gas produced with such coal was weaker. Now, this result, as we have just seen, has been reached, since the Simplex motors employ such fuel right along.

This gas obtained with coking and semi-coking coal is of sufficiently good quality to assure a proper running, but it contains tar that it is necessary to extract radically. This result will probably be obtained, but it is not as yet realized practically. It will therefore only remain to construct gas generators capable of utilizing not only coal in fragments, but also fine coal and coal dust. This, we believe, will be the last step of the progress of gas motors. It is, therefore, in this direction that the efforts of instigators should tend.

However it may be with possible economy in the future, it is possible to assert right now that considerable has just been done, since a Simplex gas motor is, under normal conditions, realizing a saving of more than half as compared with the best steam installations.—Revue Industrielle.

A CURIOUS BLOSSOM.

LATE in October a young lady student of the University of Utah brought a strangely modified marigold to the botanical laboratory. The plant was the ordinary Calendula officinalis, and, with the exception of the blossom, was like other plants of that species. Most of the ray flowers of the blossom are modified into thick, fleshy incurved horns, green in color and pubescent on the exterior surface.

The disk flowers are also green, and, with one exception, are destitute of stamens and pistils.

Nine of the ray flowers have developed into stems varying in length from three-quarters of an inch to one and a half inches. Each of these stems is crowned by a perfect blossom about half as large as a normal blossom.

The involucres of the small blossoms, as well as the involucre of the modified blossom, are perfect and normal in appearance. In the small blossoms few true disk flowers are found. Those which are not fully developed ray flowers are approaching the ligulate form, and, with few exceptions, all of them are neutral. The marigold belongs to the order Compositæ, a type of which is the sunflower.

All of the blossoms in this order have undergone profound modification. It seems probable that originally the flowers were single and at the ends of branches, but to render them more conspicuous to their insect friends, natural selection has gradually shortened the branches until now the flowers are brought together into a close head. In the flower I am describing a partial return is made to the ancestral form. Cases of such reversion, called atavism by biologists, are not especially rare, but are always interesting, as they tend to throw light on the origin of existing forms, and wherever they are found they should receive careful study.

C. A. WHITING.

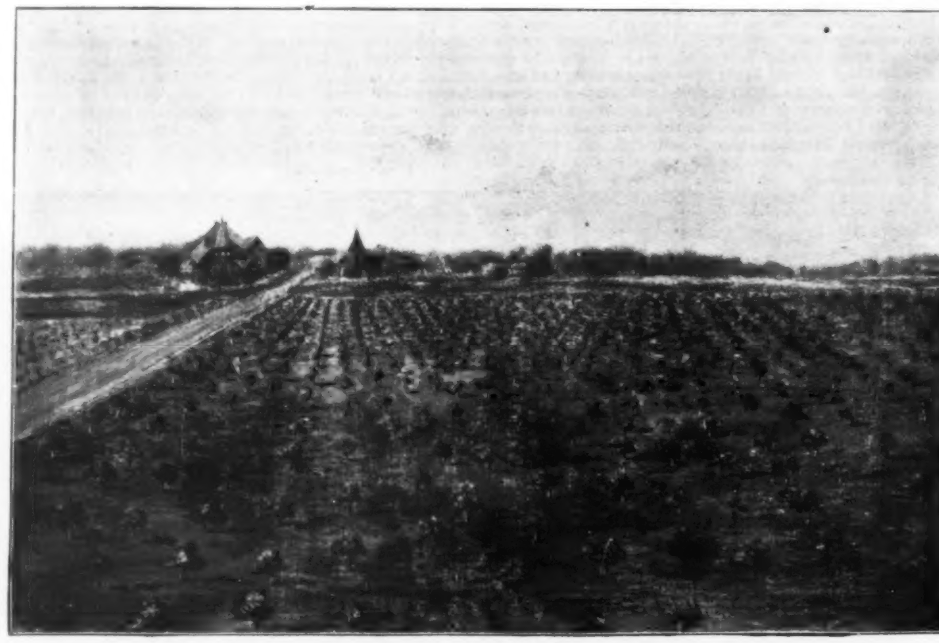
University of Utah, Salt Lake City.

CULTIVATION OF THE PECAN.

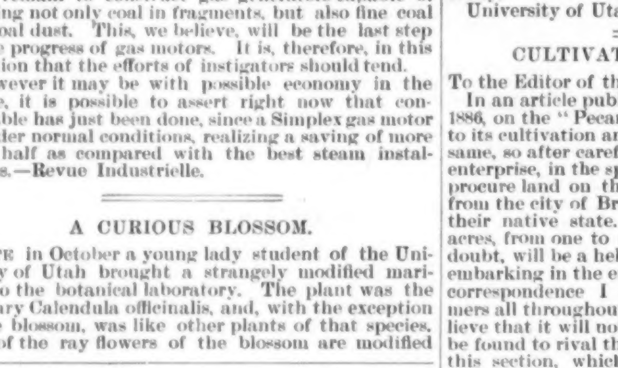
To the Editor of the SCIENTIFIC AMERICAN:

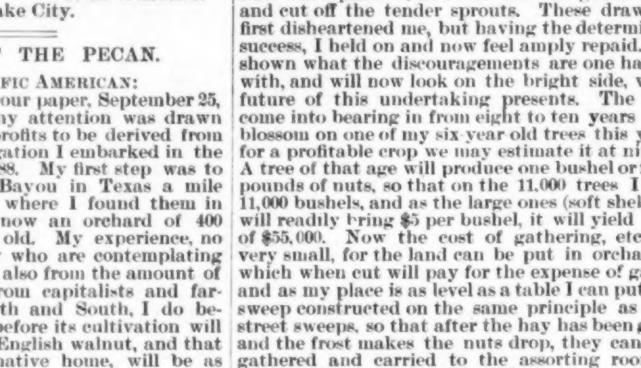
In an article published in your paper, September 25, 1886, on the "Pecan Tree," my attention was drawn to its cultivation and to the profits to be derived from same, so after careful investigation I embarked in the enterprise, in the spring of 1888. My first step was to procure land on the Pecan Bayou in Texas a mile from the city of Brownwood, where I found them in their native state. I have now an orchard of 400 acres, from one to six years old. My experience, no doubt, will be a help to many who are contemplating embarking in the enterprise; also from the amount of correspondence I receive from capitalists and farmers all throughout the North and South, I do believe that it will not be long before its cultivation will be found to rival that of the English walnut, and that this section, which is its native home, will be as famous for pecans as the Los Nietos Valley in California.

As an article of commerce, it is valuable for its timber as well as its nuts; ax and hoe handles, gun stocks, furniture and various other useful articles are made from the wood. The nut, besides being used as a dessert, is made into cakes and candies, and the oil from it is very valuable, bringing the highest price in the market, as it is used by clockmakers, gunsmiths, etc. The tree is of slow growth and long-lived; the cut shows one on my place over 100 years old in its wild state, and there is no doubt that there are trees many centuries old along this stream. The tree grows to the height of eighty or more feet and its home is in the rich alluvial valleys, but will not succeed where the soil is not rich or deep; it has a very long tap root and goes down twenty to twenty-five feet to water. There are two distinct varieties, known as soft and hard shell, the best among the soft shell variety being known as the Swinden and Stuart. The wild varieties are generally hard shelled and hardly worth planting. I have nearly 11,000 trees on my 460 acres; they are planted forty feet each way, and as there is no enterprise that is without its drawbacks, I must say I had them to begin with, the first thing being the wood louse or ant, which attacked the yellow pine stake placed by every nut; they then went from the stake to the nut and thus killed the young tree, but this was obviated by cypress boxes eighteen inches high tarred at the bottom; these boxes also served the purpose of protecting the young tree from the depredations of the rabbits and other rodents, which did me considerable damage. Squirrels will unearth the nuts when planted, and rabbits will gnaw the bark and cut off the tender sprouts. These drawbacks at first disheartened me, but having the determination of success, I held on and now feel amply repaid. I have shown what the discouragements are one has to meet with, and will now look on the bright side, which the future of this undertaking presents. The tree will come into bearing in from eight to ten years (I had a blossom on one of my six-year old trees this year), but for a profitable crop we may estimate it at nine years. A tree of that age will produce one bushel or forty-two pounds of nuts, so that on the 11,000 trees I will get 11,000 bushels, and as the large ones (soft shell variety) will readily bring $5 per bushel, it will yield a return of $55,000. Now the cost of gathering, etc., will be very small, for the land can be put in orchard grass, which when cut will pay for the expense of gathering, and as my place is as level as a table I can put a patent sweep constructed on the same principle as our city street sweeps, so that after the hay has been gathered, and the frost makes the nuts drop, they can then be gathered and carried to the assorting room, where they can be cleaned and polished, thus reducing by this process the cost of gathering, which would be nominal, if any, but for safety sake let us put it at $5,000, which would leave a net return of $50,000 on



WEST VIEW OF THE SWINDEN PECAN FARM, NEAR BROWNWOOD, TEXAS.





RESIDENCES ON THE SWINDEN PECAN FARM.

* In this regard it is well to remark that, contrary to what many persons think, the motive power of this gas resides much more in its richness in hydrocarburets than in that of its hydrogen, for the first of these gases gives about 340 calories to the cubic foot, while the second affords but 85 calories.

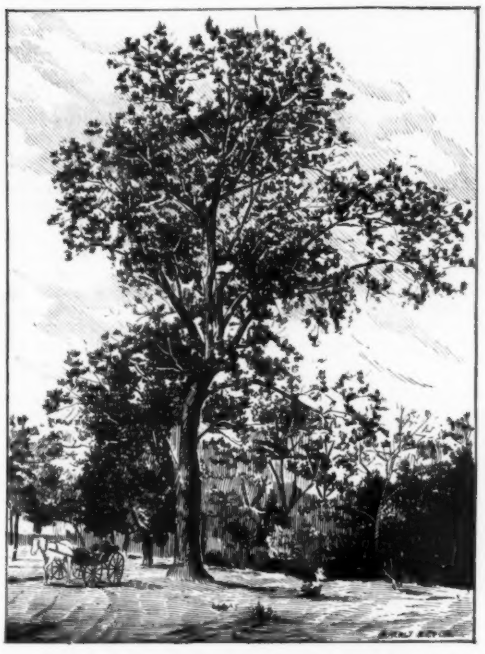
400 acres, or $125 per acre. Now, as the tree grows older, it will at fifteen to twenty years yield ten bushels or more to the tree, which would make the net profit in the neighborhood of half a million dollars. I have seen trees produce as high as forty bushels and I have paid $150 for the product of one tree. Thus we can readily draw the conclusion that the profits of the pecan will soon rival those of the famous Florida and California orange groves, as the pecan need not be rushed on the market and left to the mercy of commission men, but can be kept for two or three years if necessary and then ground into oil.

The price of the pecans varies as to quality and size, bringing from $2 to $8 per bushel, the small wild ones bringing sometimes a lower figure than $2 per bushel, while the extra large ones are in demand even at higher prices than $8.

The land between the trees need not lie idle while the trees are coming into bearing, but can be planted in corn, cotton, vegetables, melons, etc., and made to pay a surplus over expenses. I have netted on an average over $1,500 per year for the past six years from my land, but would advise none to plant wheat, oats, or alfalfa, as they sap the land and detract from the growth of the trees. Nor would I advise any one to plant in localities where there is too much rain, as the pollen is liable to be washed away, and thus keep the tree from fructifying and making fruit. I am more than pleased with my venture, and contemplate enlarging on what I have, and would conclude by saying, plant an orchard by all means, but be sure to get a suitable locality and the very best of nuts, give all the attention and care you can to the trees, and in a few years you will reap a rich reward.

F. A. SWINDEN.

Brownwood, Texas, December, 1894.



PECAN TREE ON SWINDEN PECAN FARM, NEAR BROWNWOOD, OVER 100 YEARS OLD.

ELECTRICITY AND PLANT GROWING.*

By L. H. BAILEY, Professor of Horticulture, Cornell University, Ithaca, N. Y.

PLANTS depend upon two sets of factors for their life and growth: food, supplied directly by the soil and atmosphere; environmental conditions, as warmth and sunlight. Given these agencies, plants thrive anywhere and at any time. There are certain other circumstances, however, which greatly modify the rate and direction of growth and development, without being essential to the life of the plant. It is these accessory influences and conditions which largely determine the value of cultivation; for amelioration is effected only when man adds some facility which Nature withholds. There is no absolute or fixed standard of the conditions of life, and every change in them, however slight, is reflected in some way in the plant itself. Every plant is different from every other plant, because no two of them are subjected to exactly the same conditions of existence. So it happens that every condition which comes under the dominion of man influences plants profoundly, because these conditions are thereby widely diverted from their original scope. The difference between the modification of plants in nature and in cultivation is mostly one of intensity or degree, and not one of kind; for it is only when man practices direct selection that he may adopt what may be called an unnatural or abnormal ideal. Now these accessory circumstances which diversify the vegetable kingdom are chiefly of four kinds:

1. Excess in the primary conditions of life, as an unusual or abnormal supply of food, warmth or light. This, in one form or another, is the chief means of the variation and consequently of the evolution of plants.

2. Modifications in the periodicity of diurnal and seasonal changes. Plants soon become accustomed to the circumstances in which they live, or fitted into them; and a change in this environment must inaugurate a new set of adaptations. What is called the "rest" of cultivated plants is simply an adaptation to conditions in which the plants once lived. In most parts of the globe there is a season of enforced inactivity, due to cold or dryness; and when plants are taken from these regions into greenhouses they demand a like period of inactivity. This is particularly true of bulbous plants and all those which spring from fleshy underground parts; and even with woody greenhouse plants the gardener allows a certain season when the plant is kept in a state of partial inactivity. But this season of "rest" is not a necessary attribute of vegetation, as most gardeners think, but is simply an adaptation, and in many cases it can be wholly overcome through long continued cultivation. Some plants modify themselves more readily than others in this respect, due to differences in the elasticity of their organization. If cultivation often overcomes this period of passivity, and thereby proves it to have no necessary vital function, observation of unmolested floras may show it as well, for there are certain regions in which vegetation never ceases to grow; and, furthermore, the gradation from trees to shrubs and herbs in certain species, or congeneric species, from the south to the north, shows that the duration of a plant may be determined wholly by the seasonal periodicity in which it is placed. This leads me to introduce a phenomenon which is particularly germane to the general subject that I am shortly to bring to your attention—the fact that plants undergo a diurnal variation in function. It is well known that the chief activity of the plant in daytime is directed toward the getting and making of food or assimilation, while in the nighttime it uses this food in making growth. But this, again, is only an enforced adaptation or division of labor, for, as the plant cannot assimilate in darkness, it devotes the greater part of its energies at that time to the building of tissue, and leaves itself free to "make hay while the sun shines." But both these functions may and often do proceed simultaneously; and in the long days of the Arctic regions plants complete the whole process of growth and fructification in sunlight. If we once disabuse our minds of the common belief that plants must rest at night, we shall be prepared to understand that artificial light in the hours of darkness can work no injury unless it carries with it something besides illumination.

3. Plants are modified by physical manipulation, as training and pruning and the horticultural methods of propagation; and

4. By the application of stimuli. The effects of stimuli upon plants are little known, largely because any circumstance which incites unusually rapid growth is commonly classed as a stimulant. But the term should be applied to those agencies which appear to exert some exciting influence upon the physiological processes, and not to the action of greater warmth or more food, or to any intensification of the ordinary conditions of existence. I insist upon this distinction here because it enables me to contrast two phenomena which are often confounded in their effects upon plants, but which are in essence far apart; namely, the effect of electric light, which simply adds light to light or, in other words, increases the daytime, and the electric current, or electrification, which in some way disturbs or excites the normal functions.

FIG. 1.—SWINDEN.

FIG. 2.—STUART.

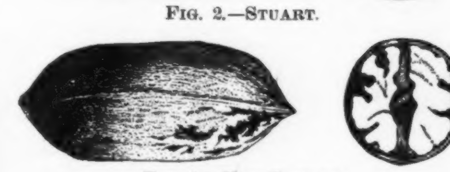


FIG. 3.—VAN DEMAN.

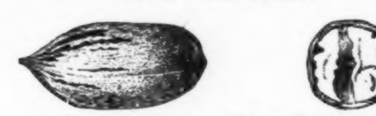


FIG. 4.—COMMON WILD PECAN.

DIFFERENT VARIETIES OF PECANS.

I. The Application of Electrical Illumination to Plant Growing.—We are now ready to approach the subject of the influence of electrical forces upon vegetation in a philosophical spirit. These forces or agencies are of two general types—the electric light, which is simply a method of illumination, and electric currents, which are a means of electrification. The former of these agencies is the one to which I invite your chief attention. We may feel sure, at the outset, that illumination at night will not injure the plant; and as it has long been proved that artificial lights exert much the same influence upon plants as sunlight does, only in smaller degree, we shall expect that good results will follow, and in proportion as the energy of the artificial light approaches the energy of solar light. The electric arc light commends itself above other common artificial lights because it is the most powerful. The spectrum of this light is that of carbon, combined, probably, with certain products of combustion. It contains the same parts as the solar spectrum and in approximately the same proportions; but it is richer in the ultra-violet rays and probably somewhat weaker in the orange rays, which accounts for its dazzling blue whiteness. It is pretty well ascertained that the orange portion of the solar spectrum is particularly promotive of the assimilative power in plants. This fact suggests that the use of an orange globe for the electric light would bring its spectrum nearer to that of sunlight. Our experiments with color screens show that an amber glass—which is the nearest approach to orange in commercial glass—gave more rapid growth or earlier results than other colors; but it is doubtful whether the assimilative power of the ordinary electric light is sufficient to render minor modifications of the visible portions of its spectrum practically appreciable in plant growth. Incandescent electric illumination has not been carefully studied in its effects upon plants, although experiments made by one of my former pupils, and yet unpublished, show that it may hasten growth. But the amount of light is much less than in the arc lamp, as the ordinary incandescent bulbs give from sixteen to fifty candle power only. But we hope to investigate the subject soon.

If the electric light, therefore, is similar to sunlight in essential effects upon plants, it remains for us to discover two things: 1. Does the light contain injurious properties along with illumination? 2. Are all plants equally susceptible to its influence?

Although Herve Mangon had demonstrated in 1861 that the electric light can occasion the production of chlorophyl or green matter in plants, and that it can produce heliotropism or draw plants toward itself, and although Prillieux had shown in 1869 that it is capable of promoting assimilation, it was not until near the close of the seventies that any application of the light to horticultural purposes was attempted. The first horticultural experiment was made in England by Dr. C. W. Siemens, a renowned physicist. Siemens experimented with a variety of forced plants, mostly those which produced edible fruits, as strawberries, tomatoes, grapes and melons. Upon all these plants the effect of the arc light was marked, sometimes injuriously and sometimes beneficially. Dr. Siemens soon found that a naked or unscreened light was injurious to plants at short range, but that the interposition of a clear glass globe or an ordinary window pane prevented such injury. He demonstrated that the light can be placed above the house with good results, and thereby also showed that the modification of the plants was due to illumination and not to electrification nor to products of combustion. In general, plants were earlier under the screened light than in natural conditions; that is, they grew more rapidly, and this is the result which we should have anticipated, if it is true that the electric light simply lengthens the day. At the close of his experiments Siemens was very sanguine that the electric light can be profitably employed in horticulture, and he used the term "electro horticulture" to designate this new application of electric energy. He anticipated that in the future "the horticulturist will have the means of making himself practically independent of solar light for producing a high quality of fruit at all seasons of the year." He had shown that growth can be hastened by the addition of electric light to daylight, that injury does not necessarily follow continuous light throughout the twenty-four hours, that electric light often deepens the green of leaves and the tints of flowers and sometimes intensifies flavors, and that it aids to produce good seeds; and he thought that the addition of the electric light enabled plants to bear a higher temperature in the green-houses than they otherwise could bear. But whatever may be the value of the electric light to horticulture, the scientific value of Siemens' experiments is still great. They have furnished data in regard to several obscure relations of light to vegetation. Nature made the following comments upon this feature of the application of the electric light by Dr. Siemens: "But the scientific interest of its present application must rest mainly on the fact that the cycle of transformation of energy engaged in plant life is now complete, and that, starting from the energy stored up in vegetable fuel, we can run through changes from heat to electricity, and thence to light, which we now know we can store up in vegetable fuel again." While the experiments were designed for practical purposes, and while the economic results seemed to be important, the most valuable conclusions of these signal investigations are such as concern the purely scientific questions of the interrelations of plants and electrical illumination.

While Siemens was concluding his experiments in England, Deherain was conducting similar ones in Paris; but while Siemens had attempted only to supplement daylight by electric light for a part or all of the night, the other endeavored to grow plants by the continuous electric light alone, with practically no aid from the sun. He found at once that the naked arc injures plants, even though it promotes assimilation more rapidly than the screened light. Barley in head and flax in flower were brought into the lighted compartment; also chrysanthemums, pelargoniums, roses, and a variety of ornamental plants. After seven days of continuous electric lighting most of the plants were seriously injured. All the pelargoniums lost their leaves, cannas were discolored, four o'clocks were tarnished, and bamboos were blackened. "But the most curious effect was produced upon the lilacs; all the parts of the leaves that had received the direct rays from the lamp were blackened, while those protected by the upper leaves preserved their beautiful green color, and the impression produced upon the epidermis by the electric rays had the clearness of a photographic plate." Similar effects were produced upon azaleas, deutzias, and chrysanthemums. It was found that this discoloration did not extend beyond the first layer of palisade cells. Plants which received solar light by day and electric light at night only, were injured in the same manner but in a less degree. The injury was most marked upon the old leaves. The pelargoniums soon sent out new shoots and the young leaves resisted the action of the light much longer than did the mature ones. The flax continued to grow and the barley ripened. It was found that plants under the electric light alone were able to assimilate, but the action was very slow. As much assimilation took place in an hour on a bright summer day as in several days of electric light. At the expiration of two weeks the condition of the plants was so bad that a change was made, and thereafter a globe was used upon the lamp. Deherain also found that while established plants may continue to live and even

* From the transactions of the Massachusetts Horticultural Society.

to grow when exposed only to an electric light, sprouting seeds die before making true leaves. The functional difference between the germinating seed and the independent plant is expressed by the fact that in the former oxygen is freely absorbed and carbonic acid gas is given off, while in the mature plants the reverse is true in the main—carbonic acid gas is freely taken in and oxygen is freely given off; but it is not known whether these processes are concerned in the widely different effects which the light exerts upon these stages of vegetation. I have also observed an injury to follow in exposing very young plants to the arc light, but I cannot account for its cause. Deherain's general conclusions in regard to the influence of electric light upon plants are as follows:

"1. The electric light from lamps contains rays harmful to vegetation.

"2. The greater part of the injurious rays are modified by a transparent glass.

"3. The electric light contains enough rays to maintain full grown plants two and one-half months.

"4. The light is too weak to enable sprouting seeds to prosper or to bring adult plants to maturity."

At this point our own experiments were projected. These were begun in January, 1890, and have been continued uninterruptedly during the forcing season to the present time. I shall now invite your attention to a general survey of these investigations, referring you to our three bulletins upon the subject for the details. I confess that I had expected to be able to reach definite conclusions at the close of the first winter's experiments; but at the present time, while we are engaged in the fifth annual series of investigations, we find ourselves still very far from definite conclusions concerning some of the primary and fundamental phenomena of the experiments. For four winters we endeavored chiefly to grow crops by the aid of the light, and although we have succeeded with several species, we have now given up for the time being all commercial or so-called practical considerations, and we are now endeavoring to discover the fundamental facts concerning the exact composition of the arc light, and its direct action upon vegetable tissue and physiological processes. Although this may seem to be driving the cart before the horse, it is nevertheless the necessary and logical order of experiment in untraveled fields, because we have first to discover the phenomena before we can search for their causes.

Our first experiment was with a naked two thousand candle power lamp hung inside a forcing house and running all night. A forcing house sixty feet long and twenty feet wide was divided by a partition, one part being run in the ordinary manner, the other receiving electric light at night in addition to the normal daylight. The general effect of the light was to greatly hasten maturity, and the nearer the plants grew to the light the greater was the acceleration. This tendency was particularly marked in the leaf plants, endive, spinach, cress, and lettuce. The plants "ran to seed" before edible leaves were formed, and near the light the leaves were small and curled. This is well illustrated in spinach. The electric light spinach matured and produced good seeds while that in the dark house was still making large and edible leaves, with no indication of running to seed. An examination of leaves of the plants under the microscope showed that while there was apparently the same amount of starch in each, it was much more developed in the electric light specimen, the grains being larger and having more distinct markings, and giving a better color test when treated with iodine. Lettuce, growing in a row nearly under the lamp, behaved in a similar manner. For three feet either side of the lamp, most of the plants were killed outright soon after they came up, and the remaining ones in the entire row (thirty-five plants) were seriously injured, the leaves curling and remaining very small. The plants increased in stature, vigor, and size of leaves with increased distance from the lamp. Those nearest the lamp made most leaves early in their growth, and they maintained this advantage until about four weeks old, although the leaves were smaller. Five weeks after sowing, the average height of the plants within four feet of the lamp was 1·2 inches; between four and five feet, 1·34 inches; between five and six feet, 1·8 inches; between six and seven feet, 2 inches; between seven and eight feet, 2·2 inches. The average height of plants in the dark house at this time was 2¼ inches, and the plants were much more vigorous, and had larger and darker leaves. The increase in size was not uniform with increase in distance from the lamp. There were somewhat regular alternations of lower and higher plants, although there was a general progression in height. This alternating elevation and depression was probably due to the concentric bands of varying intensity of light which fall from the arc, and which are caused by the uneven burning of the carbons, those zones which were marked by the shadow giving the better results in growth. Cress and endive gave similar results. With endive we chanced to get a signal illustration of the injurious effect of the light. One of two parallel rows of plants was in the shade of a post, and while the exposed row gradually increased in size as it proceeded from the light, this shaded row gradually decreased, or was largest nearest the light where the shadow was most intense.

Some of the most marked results in this first series of experiments were obtained with the radishes. The young radish plants were strongly attracted by the light, and in the morning they all leaned at an angle of from 60° to 45° toward the lamp. During the day they would straighten up, only to reach for the lamp again on the succeeding night. This was repeated until the roots began to swell and the plant became stiff. As the plants grew, the foliage became much curled, and the amount of this injury was in direct proportion to the nearness to the lamp. Those nearest the lamp—within three or six feet—were nearly dead at the expiration of six weeks, while those fourteen feet away showed little injury to the leaves. The crops obtained in the dark or normal house were about twice greater than those in the light compartment. The entire plants and the tops were almost half lighter in the light house, and the tubers were more than half lighter, while the per cent. of tubers large enough for market was as nine in the light house to twenty-six in the dark house. And it should also be said that the average size of the tubers graded as marketable was less in the light house than in the other. A portion of a plantation of radishes in the light house was protected by the fan-shaped shadow cast by an iron post an inch and a half in diameter. In the shadow the foliage was scarcely injured, while those leaves which projected into the light were curled. Chemical analysis showed that the plants under the electric light had reached a greater degree of maturity than those in the normal or dark house. The ash was more, potash more than double, chlorophyl (including extracted gums) somewhat more. The total nitrogen was essentially the same in all samples, but it is noticeable that in the electric light plants more of the amide nitrogen had been changed into other forms than in the other sample; and the electric light samples were richer in albuminoids. The light house plants from the shadow were much nearer in composition to those in full light than to those in the dark house.

Dwarf peas in the light house, particularly those in direct light, blossomed about a week in advance of those in the dark house, and they gave earlier fruits, but the productiveness was less, being in the ratio of four in the light house to seven in the dark house; and the plants were considerably shorter in growth. The decrease in production was due largely to the fewer peas in each pod, for the number of fruitful pods produced in each case was as seven in the light house to nine in the dark house, and there were many seedless pods in the light house. In other words, the production of pods (or flowers) was about the same in both houses, but the plants in the light house produced only four-sevenths as many seeds as those in the dark compartment.

Carrots gave wholly indifferent results. They did not appear to be affected greatly even by the naked light, though growing but three or four feet away. Carrots require a long period of growth, and were therefore exposed to the light for about four months, and yet the plants which grew directly in front of the lamp were but little inferior to those which stood ten or twelve feet away, or even to those in the dark house. No other plant in our experiments has withstood the electric light so well.

Here, then, was proof that two distinct series or classes of results proceeded from the naked electric light; plants are injured, and they are forced into earlier maturity. We are, therefore, able to answer the two questions which we asked ourselves at the outset: 1. There is other influence than mere illumination in the electric light. 2. Different plants are differently affected by the light.

It now remains for us to determine how to avoid or correct the injurious effects while we still hold to some of the accelerating influences of the light; and we must also ascertain what plants most readily adapt themselves to such changed conditions of life as the electric light introduces.

Both Siemens and Deherain found that ordinary glass cuts off many of the higher refrangible or ultra-violet rays in which the electric spectrum abounds and which are too intense for the welfare of most plants. Common glass has this property in a marked degree, and it cuts off many of these rays in the solar spectrum. In our next experiment, therefore, the injurious portion of the light was cut out by a globe surrounding the arc. We first tried an opal or whitened globe, and the light, as before, ran all night. There was at once a marked change. The effect of the modified light was much less evident than that of the naked light. Spinach showed the same tendency to run to seed, but to a much less extent, and the plants were not affected by proximity to the lamp. Radishes were thrifty in the light house and the leaves did not curl, but they produced less than in the dark house, though the differences were much less marked than in the former experiments. The loss in growth of radishes due to the electric light averaged from one to five per cent. in the screened light, while the loss occasioned by the naked light had been from 45 to 65 per cent. It was noticeable, also, that while the tops or leaves were lighter under the naked light, they were heavier under the modified light than those of normal plants; and this is interesting in connection with the fact that lettuce did much better under the modified light than in normal conditions.

We had now prevented most if not all of the secondary injurious influence of the light due to the ultra-luminous portion of the spectrum, and we had found one plant—the lettuce—which was able to adapt itself completely to the new conditions, and, by availing itself of the added light, had been greatly benefited. The other plants were unable to adjust themselves to the accelerated assimilation, and ran too quickly to seed, or matured before they had attained a normal stature. The next logical step, therefore, was to run the light only a portion of the night, in order that the change from normal conditions should not be too violent.

The third stage of our experimentation, then, concerned itself with the naked light running the first half of the night. The foliage of radishes was noticeably larger in the electric light house, as it had been before under the modified light, but the tubers were practically the same in both houses, and the date of maturity was the same. Notwithstanding its greater size, the foliage in the light house showed some signs of curling. Peas were grown, and in every case they were larger and more fruitful in the dark house. The electric light did not increase the size of leaves, as it did in the radishes. These results, also, are similar to those obtained in previous experiments.

Lettuce, however, was greatly benefited by the electric light. We had found that under the protected light running all night, lettuce had made a better growth than in normal conditions, but now it showed still greater difference. Three weeks after transplanting lettuce of equal age upon the benches of the light and dark houses, the plants in the light house were fully 50 per cent. in advance of those in the dark house in size, and the color and other characters of the plants were fully as good. The plants had received at this time 70½ hours of electric light. Just a month later the first heads were sold from the light house, but it was six weeks later when the first heads were sold from the dark house. In other words, the electric light plants were two weeks ahead of the others. This gain had been purchased by 161¾ hours of electric light, worth at current prices of street lighting about $7.00. This experiment was repeated by reversing the houses for the purpose of eliminating errors, and the results were essentially the same. Seeds were sown in flats, Feb. 24, 1891. Until March 17, they were grown under ordinary conditions, at which time they were set in their permanent positions in the two compartments. We began to pick lettuce from the light house April 30, but the first of equal size from the dark house was obtained May 10. The electric light plants were, therefore, upon the benches forty-four days before the first heads were sold. During this time there were twenty nights in which the light did not run, and there had been but eighty-four hours of electric light, worth about $3.50. This gain of ten days in maturity is remarkable when we consider that the light never ran later than eleven o'clock at night; that nearly half of the nights had no light, and that the experiment was made late in the season, when the strong sunlight tends to obscure any effect of the artificial illumination. These results were uniform throughout a house 20×30 feet in extent, in both instances.

All subsequent experiments strongly confirm these results; and nothing can be more definitely stated concerning the effects of electric arc light upon vegetation than that a 2,000 candle power lamp, run half the night, or even less, exerts a most marked beneficial influence upon lettuce throughout a house sixty feet square. In fact, I consider this point so well established that we have discontinued experiments in the general forcing of lettuce by the electric light.

(To be continued.)

EARLY BRITISH RACES.*

By J. G. GARSON, M.D., V.P. Anthrop. Inst.

BEFORE proceeding to trace the early history of man in Britain it is necessary to refer briefly to the physical changes which geologists tell us have occurred since the close of the tertiary period in the configuration and temperature of the northwestern portion of Europe.

At the beginning of the Pleistocene period the temperature of northern Europe became colder and an ice cap, like that which now covers Greenland, gradually extended itself, probably as far south as Middlesex and covered the greater part of Wales and the northern half of Ireland. This is known as the Great Ice Age. At that time, the land being more elevated than now, Great Britain and Ireland formed part of the continent of Europe, and the western coast line extended some three or four hundred miles further into the Atlantic Ocean than it does at present. This period of cold was gradually succeeded by a more genial one, during which, but before the ice had disappeared, a great depression and submergence of the land took place, varying from about 600 ft. to over 3,000 ft. below the present level at different parts of the country, but least in the south of England. The climate again became colder, and on the higher parts of Wales, the north of England and in Scotland glaciers were once more formed, but not to the same extent as formerly. Then followed, in late Pleistocene times, a re-elevation of the land to at least 600 ft. above its present level, and Great Britain and Ireland once more became joined to the Continent, and the climate became temperate. In all probability the geographical conditions of Britain, or rather the British corner of Europe, in early and late Pleistocene times were almost identical. Finally the land connection with the Continent became severed by submergence till almost the present coast line was reached, and the sea once more rolled in over the beds of the German Ocean and the English Channel. These changes in the geographical conformation of the northwestern part of Europe took place slowly, and were consequently spread over an immense interval of time.

According to some eminent geologists, man first took up his abode in the British portion of Europe, either during the early glacial or pre-glacial period. The evidence of his existence here at that early period rests upon the discovery of many flint implements of peculiar and special type on certain high chalk plateaux in Kent, in drift resting on Pleiocene beds, in drift deposits of Norfolk and Suffolk, and in certain caves in which glacial drift is believed to be deposited over the flints. All these implements are of the rudest make, more or less stained, like the drift flints with which they are associated, of a deep brown color. They show a considerable amount of wear, as though they had been rubbed and knocked about a good deal, so that the worked edges are commonly rounded off and blunt. In few instances have they been wrought out of larger flints, and the amount of trimming they have received is generally slight, and has been made on the edges of rude natural flints picked up from old flint drift; indeed, sometimes the work is so slight as to be scarcely apparent, in other specimens it is considered by some sufficient to show design and object. These implements indicate the very infancy of art, and are probably the earliest efforts of man to fabricate tools and weapons from other substances than wood or bone. They give us some slight insight into the occupations and surroundings of the race who used them, as they appear to have been used for breaking bones to extract the marrow, scraping skins, and rounding sticks and bones for use as tools or poles. From the absence of large massive implements, it would seem as though offensive and defensive weapons had not been much needed, either from the absence of large mammalia, or from the habits and character of these early people. Many archæologists are not satisfied with the evidence yet adduced as to these flints being of the early date claimed for them, consequently of man's existence in Britain at that time, and regard the implements just described as belonging to the early part of the next period.

Whatever may be the ultimate decision arrived at as to the age of these flints, all geologists and others are agreed that after the glacial period had passed away and Britain had once more become a part of the continent of Europe after its submergence, a race of men known to us as Palæolithic man migrated into the country from the Continent, across the valley of the English Channel. Man of this period is known to us from various remains of him found in drifts of post-glacial age, and in the lower deposits of certain caves. As some evidence has been brought forward to show that the river drift people, as they are called, are earlier

* Read at the evening meeting of the Royal Institution, April 20, 1894, London.

than the cave dwellers, we will consider the remains of the former people first.

Remains of man from British river drifts have only been found in the south of England from Chard, Axminster, and the Bristol Channel in the west, to the Straits of Dover, the lower Thames, Suffolk and Norfolk on the east, and as far north as Cambridge. They are conspicuous by their absence northwest of a line passing from Bristol to the Wash. The remains consist of a small portion of a skull reputed to be of this period, implements of flint, quartzite and chert, antlers of deer, and of certain fossil shells, probably used as ornaments.

The portion of skull was found by the late Mr Henry Prigg, in 1892, at Westley, in Suffolk, seven and a half feet from the surface, in a pocket of brick earth eroded in the chalk, and in an adjoining pocket two molar teeth of mammoth and four Palæolithic flint implements were found.* The fragment of skull was part of the vertex, and included the upper portions of the frontal and parietal bones with part of the coronal and sagittal sutures. It was examined by Mr. Worthington Smith, and in transit back to the finder of it was unfortunately smashed. As it was not a characteristic part of the skull, it shed little light on the cranial characters of its owner. With this exception, no human bones have been found in fluviatile deposits in Britain.

The implements from the river drift consist principally of oval-pointed flints which have been fashioned by chipping, and were used without handles, oval or rounded flints with a cutting edge all round, scrapers for preparing skins, pointed flints used for boring, flakes struck off from blocks or cores by means of large hammer stones, often of quartzite, and choppers of pebble chipped to an edge on one side. The tools with which these implements were manufactured consisting of anvil stones of large blocks of flint, pointed flints or punches, and carefully made fabricators. All the implements, though simple and rude, show signs of manufacture, the more finely finished specimens having been prepared by chipping. Their manufacture seems to have been carried on at certain localities on the banks of rivers, and other places where there was plenty of material from which to make them. It will be observed that at this time there were no flint arrow heads, and that man was but poorly equipped for the chase, although it was undoubtedly by that means he gained his livelihood. Besides these flints man doubtless used wood and bone implements; pieces of pointed stakes made of wood have been found on the Palæolithic floors where he worked by Mr. Worthington Smith. Bead-like fossil shells of Coscinopora globulosa have also been found by Mr. Smith, with artificial enlargement of their natural orifices, among his implements, which would indicate that they had been used for necklaces or ornaments, so that he seems not to have been unmindful of his personal adornment even at that early time.

It is of importance to consider for a moment the animals which lived with man at this period. There are found in the same strata with him remains of the hippopotamus, two species of elephants and of rhinoceros, the cave bear and lion, the wild cat, hyena, urus, bison, the wild horse and boar, stag, roe, reindeer, and other animals, many of which are now extinct. Man at that time had no domestic animals. The only clothing he had, if he wore any, was made from the skins of the animals which he killed in the chase and used for food. Being far from the sea, if he used fish as food, they would be such as he was able to catch in the rivers.

Let us now trace man of this period on the Continent. In the fluviatile deposits of the Somme and the Garonne stone implements have been found and recognized by such competent authorities as Sir John Evans, Mr. Franks, Professor Boyd Dawkins and others, as identical with the drift Palæolithic implements found in England; similar ones have been found in Spain, near Madrid, in Italy, Greece, Germany, and other places in Europe, also in northern Africa, Palestine and India. From these finds we learn that man has lived in a similar state of civilization to what he did in Britain, over a very wide area; they also show that he must have remained in this stage of culture for a very long time; but they give no evidence that the places where they are found were once inhabited by one and the same race of people, as might be inferred from some authors.

As regards his skeletal remains on the Continent, but few have been found. At Canstadt, near Stuttgart, it is stated that a portion of a skull was discovered in 1700, in deposits presumed to be of Palæolithic age, with bones of the cave bear and hyena, and mammoth.† At Eguisheim, near Colmar, Schaffhausen, a portion of another cranium was found with mammoth and other animal remains of this period. At Clichy, in the valley of the Seine, a skull and some bones were found at depths varying from 4 to 5·4 meters from the surface, in undisturbed strata with mammoth, woolly rhinoceros, horse and stag. The skull in these instances is long and narrow in shape, with prominent supra-orbital and glabellar ridges; the thigh and leg bones of the Clichy skeleton are laterally compressed, the former having a greatly developed linea aspera, the latter being markedly platycnemic. Further reference will be made to these specimens when we deal with the cave skeletons.

Caverns and rock shelters are well known to have been used not only by man but also by animals from remote times down to the present day. The strata which have been deposited in them at different times by their successive occupants and the vicissitudes of climate are often well marked and give much valuable and reliable information, but great care is required in discriminating the different periods which their contents represent. The remains of Palæolithic man deposited in caves are much more widely distributed over England than those from the river drift, having been found as far north Yorkshire and Derbyshire, in North and South Wales, Gloucestershire, Monmouthshire, Somersetshire, and Devonshire, also in Ireland, although these latter have not been much worked. The Palæolithic cave stratum shows three sub-strata: in the two lower ones the flint implements are precisely similar to those of the river drifts, but flat pebbles of quartzite are also found with part of the natural smooth surface retained, while the rest is chipped and fashioned into an implement. In the upper sub-stratum more highly finished articles, which would point to a higher and probably a different social condition later in time, are obtained. We have in this higher sub-stratum flints of a lanceolate form, trimmed flakes, borers, and rounded hammer stones. These are of smaller size than the earlier implements, and some of them had evidently been let into handles of wood. Bone needles, with an eye bored at one end, bone awls, scoops, and harpoons barbed on one or both sides made of deer's antler are also met with. Of great importance are the representations of animals, which have been found incised on bone, for example, the portion of a rib with the incised figure of a horse upon it found in this layer in Robin Hood Cave in Derbyshire.

No portions of the human skeleton have been found in the Palæolithic stratum of British caves, except a single tooth.

On the Continent many caves have been discovered in France, Belgium, Germany and Switzerland, with similar deposits and implements to those found in England, and showing also the same two stages of culture. More numerous examples of figure carving of the same type as that found in the Derbyshire cave have been obtained in French caves, and the teeth of carnivorous animals and shells, both artificially bored for ornaments.

By associating British and Continental evidence, we can form a good idea of the mode of life of the cave dwellers of Palæolithic times. The caves gave him shelter in cold weather, from which he also protected himself by fires, and clothing made from the skins of animals secured in the chase sewn together by means of bone needles threaded with shreds of the tendons of reindeer.

Armed with flint-tipped spears, and daggers of bone ornamented with carved handles representing the chase, he lived by hunting the reindeer, the wild horse and the bison; he also lived on birds and fish, which he speared with barbed harpoons. The game brought home was cut up with flint knives and cooked, and the long bones were broken with heavy flints for the marrow they contained, which was evidently considered a delicacy. The manufacture of the flint implements he used when engaged in the chase must have formed an important part of his work. The ornamental carvings on bone which he frequently made show that he was an artist of no mean order in depicting animals, but give us little information regarding his own morphology, as they seldom bear representations of himself—when they do, only his miniature outlines are figured naked; the carvings also show that he was in the habit of wearing long gloves to cover his hands and arms. Probably he painted his body of a red color, and ornamented himself with perforated shells, pieces of bone, ivory and teeth. Like the river drift people he posessed no domestic animals, not even a dog to assist him in hunting.

In Continental caves human skeletons of this period have been found; of these, perhaps, the best known is the famous Neanderthal one, from a cave near Dusseldorf. Upon this skeleton alone it would not have been prudent to have based the characters of Palæolithic cave men, because the circumstances under which it was found have given rise to some doubt as to its being of this age, and it is considered by some to belong to the next period which we have to deal with. When it is taken in conjunction with others presenting similar characters, and regarding which there can be no doubt as to the age to which they belong, the evidence it affords is considerably strengthened.

The find of two skeletons at Spey in Belgium in 1886 has been most important, both in advancing our knowledge and confirming the characters ascribed to this race from various less complete specimens. The cranium of the Neanderthal skeleton, though very imperfect, is long and proportionately narrow in form, having a cephalic index of 72, the glabella, brow ridges and external orbital processes are enormously developed, the forehead is remarkably flattened, the occiput is prominent and the elevation of the whole vault is extremely low.

The skulls of both the Spey skeletons are also long and narrow, one having a cephalic index of 70 and the other of 74·6, the superciliary ridges, and also the glabella, are very prominent, the frontal sinuses are large, the external orbital processes are thick and projecting, the ridges on the frontal, parietal and temporal bones for muscular attachments are strongly developed, the occiput is prominent with a well marked "torus" at the junction of the curved muscular ridges, which are also large, the cranial vault is low and flattened from above downward, and presents an antero-posterior curve very similar to the outline of the side of an ellipse; the malar bones have thick and broad orbital processes, the orbital cavities are deep, and the orbital breadth is but slightly inferior to the width, the zygomatic arches are large. The size of the lower molar teeth increases from before backward, the first molar being the smallest, and the last molar the largest.

The lower jaw shows no prominence of the chin, indeed, it recedes somewhat from the alveolar border downward, and has a symphesial angle of 111°. It is thus a counterpart of the Naulette mandible, which presents similar characters, both as regards the molars and the symphesial angle.

The stature of the Neanderthal skeleton, estimated from the length of the femur, is 1·640 meters (5 ft. 3 in.), and from the humerus 2 centimeters less; that of the Spey skeleton (there being only one of these in which the long bones could be measured), estimated from the femur and tibia, is 1·504 meters (4 feet 11¼ in.), and from the femur alone, 1·540 meters (5 ft. ¾ in.) The stature of the Naulette skeleton, that of a woman, estimated from the ulna, is 1·433 meters (4 ft. 4⅛ in.), and shows that she also was very short.

The long bones of the upper and lower limbs of the Neanderthal skeleton are characterized by their unusual thickness and the great development of the elevations and depressions for the attachment of muscles, the articular ends of the femur are of larger size than usual. The femur of the Spey skeleton is more arched forward than usual, somewhat flattened from side to side in section, and the articular ends are of large size, especially the lower, in which there is enormous antero-posterior development of the articular surface of the condyles. The tibia is actually and proportionately very short, flattened laterally, and therefore platycnemic. The bones generally are remarkable for their stoutness, and indicate that the muscles attached to them were large and powerful, especially those of the lower limb. In respect to the platycnemism of the tibia, the Spey skeleton corresponds to the Langerie Basse and Madelaine bones from the Perigord caves, and confirms in a very positive manner the evidence of their surroundings and relics that Palæolithic people were sons of the chase, as it is connected with the development of the tibialis posticus muscle, and not a race character.

Portions of skulls and skeletons found in various parts of the Continent, associated with Palæolithic implements and animal remains of late Pleistocene times, support the peculiar race characters of the specimens just described. The osteological remains of Palæolithic age now in hand, from different parts of the Continent, seem to me to afford sufficient evidence of the existence both in drift and in cave deposits of a race of men possessing physical characters quite distinct from those of the Neolithic period, which we will next consider. The assertions which have been made at various times with respect to individual specimens being more or less pathological will, to my mind, not hold good when we find specimen after specimen from the same deposits showing similar characters. It may not be possible in some cases to establish the fact that the specimen cannot have been deposited at a later period in the stratum in which it is found, but a careful examination of each specimen, such, for example, as Professor Topinard has made of the mandible from Naulette, shows anatomical conditions which, not in one respect, but in several, indicate as distinctly as his implements the progress of man's evolution, and preclude the idea of this type being a variety of the Neolithic people. The specimens of Palæolithic man seem to me to show identity of race, whether they have been found in the river drift or in the Palæolithic stratum of caves. The idea of Professor Boyd Dawkins, that the implements found in the river drifts and later Palæolithic deposits of caves give evidence of there being two Palæolithic races, is not supported by the osteological remains yet to hand. From extensive examination of ancient British skeletons, I do not consider that there is any evidence of the existence of the direct descendants of Palæolithic man among the osteological remains of Neolithic or subsequent date in Britain. Here he seems to be as extinct as many of his contemporary animals of the late Pleistocene period; this may or may not be the case with respect to his existence in other parts of Europe. Whether he has still representatives in America, as surmised by Professor Boyd Dawkins and some American anthropologists, is an interesting question, but does not come within the scope of this lecture.

The next period at which we find remains of man in Britain is separated from the previous one by a space of time measurable only by the changes occurring in the interval. Great Britain and Ireland had again become islands almost of the same dimensions as at the present day, but with a moister and more continental climate—hotter in summer and colder in winter—abundant forests extending as far as the extreme north of Scotland, and numerous morasses and peat bogs. Not less significant was the advance in civilization man had made since Palæolithic times, as we now find him dwelling in fixed habitations, with a knowledge of the arts and agriculture, with domestic animals, and with stone implements not only of the earlier type but of a much more developed character, as he had now learned to smooth them by grinding and polishing.

These Neolithic people, as they are called, lived on the tops or sides of hills or in suitable valleys. Their camping grounds were intersected with numerous drains or ditches, which would show that the climate was moist. Inside the camp they hollowed out pits, in or round which they dwelt. From these camps have been obtained spindle whorls and bone combs toothed at one end, showing that they were acquainted with the arts of spinning and weaving, bone needles, fragments of coarse pottery made by hand and not turned on the wheel, either plain or ornamented with simple lines or dots, bones of the roe, red deer, dog, goat, short horned ox, horse, pig, etc., and fish, but no trace of metal is found. Of all their implements, the stone ax is, perhaps, the most important. Flints used for implement making were now often quarried from below the soil, with antlers of deer as picks. The implements were distributed over districts far removed from where they were made, probably by barter; thus, jadite or nephrite implements have been found in Britain, which Mr. Rudler has shown were probably obtained from Switzerland, Silesia or Styria. They possessed canoes formed out of the trunks of trees, in which they probably reached this country from the Continent.

They buried their dead in caves which had been used as dwellings, in their camps, and in chambered and unchambered barrows. The most characteristic British barrows of this period are of long oval shape, and often of large size, but Neolithic interments are also found in circular barrows. The dead were buried in a contracted or crouched position, and, with them, stone and bone implements of various kinds, and pottery, which would seem to show that these articles were intended for the use of the dead or their spirits. Relics of art in the form of carvings are seldom found, and are very inferior to those of late Palæolithic times.

Osteological remains of the Neolithic people are distributed all over Britain, from the south of England to the extreme north of Scotland. They are most numerous in the southwest of England, especially in Wilts and Gloucestershire, the part of the country occupied by the Drobuni or Silures at the beginning of the historic period. They have been found in considerable numbers in Yorkshire, Derbyshire and Stafford. Huxley and Wilson have described the same race from horned cairns in Caithness, and from other places in Scotland. I have described them from Wiltshire, Middlesex, Yorkshire, and from Orkney.

There is some doubt of their existence at an early period in Ireland, as Professor Macalister informs me that he has not recognized them, and no long barrows

† Jour. Anthrop Inst., vol. xiv., p. 51.

‡ Since this was written Professor Boyd Dawkins has informed me that in the original record of the finds made at Canstadt in 1700 there is no mention of this skull having been found, and that the first mention of it having been found with them is in 1835. M. Cartailhac gives this latter date as that when the skull is first mentioned

are found there. Sir William Wilde, on the other hand, recognized Neolithic skulls from Somersetshire as identical with certain ancient Irish skulls. Any skulls from Ireland I have seen which have shown characters similar to the Neolithic skulls from England are of later date, but Huxley describes them from chambered tombs, peat mosses and river deposits of Ireland, of the long, narrow type. I think we may conclude as regards Ireland, that although it is doubtful whether the Neolithic people were there at as early a date as in Britain, certainly they were there later.

The characters of the skeletons are well marked. The skull is large and well formed, the calvaria is long and proportionally narrow, having a cephalic index of about 70, and of oval shape. The superciliary ridges and glabella are moderately or even feebly developed, the forehead is well formed, narrow and curves gracefully to the occiput, which is full and rounded. The upper margins of the orbits are thin, and the malar bones are never prominent, the profile of the face is vertical, and there is no tendency to prognathism, the chin is prominent, the symphesial angle is from 70° to 80°, the length of the face from the root of the nose is comparatively short, but, as a whole, it is oval in form; the jaws are small and fine, the teeth are of medium size and generally in a good state of preservation, not much worn down; the last molar is the smallest tooth of that series. The facial characters are mild and without exaggerated development in any one direction; the same may be said of the calvaria generally. The age of the persons to whom they belong averages, according to Dr. Thurnam, forty-five years, which would seem to indicate that the duration of life at that time was rather short.

The stature of the Neolithic people is short. From Dr. Thurnam's measurements of the femora of twenty-five skeletons, it averages 1·674 meters (5 ft. 6¼ in.) by Rollet's formula, but from my own observations on other specimens which have passed through my hands, I am inclined to consider this is too high an average. In their general characters the bones are slender, often with a well-marked linea aspera on the femur and platycnemic tibia, which would show that the Neolithic people still led a very active life as hunters. Dr. Thurnam has noted that sometimes two or more of the cervical or dorsal vertebræ have a tendency to anchylosis, but I cannot say that I have ever seen this.

On the continent of Europe remains of the Neolithic people are found chiefly in caves, and show much the same state of culture and physical features as just described—as, for instance, the well known Cro-Magnon and Engis skulls; but the sequence of their existence there is not so well defined as in Britain, where they held, apparently, undisputed possession of the country for a considerable period. Indeed, it is only lately that Continental anthropologists have admitted their priority to that of people presenting the characters of the next race we shall have to deal with.

From the evidence to hand, it seems probable that the Neolithic people at one time occupied the whole of the west of Europe; and I agree with several other observers in considering that they are to be identified with the old Iberian race, of which the Basque may be considered a remnant. There is, certainly, a strong similarity between Basque skulls and those of the Neolithic people of Britain.

Unlike Palæolithic man, the Neolithic people have never become extinct in Britain, and their descendants exist to the present time.

It is true that subsequent invaders drove them in many instances to particular parts of the country, where they remained isolated for a long period, as early history and the excavations of General Pitt Rivers and others show, but skeletons from ancient tombs indicate that they also mixed with their conquerors. The observations of several anthropologists show that they are associated with the short, dark-complexioned and dolichocephalic people found in considerable proportions in some parts of the country, especially in certain parts of the west of England.

The next people to appear upon the scene previous to the dawn of history are those who were in possession of the greater part of Britain at the time of the Roman invasion. They came into Britain from northern France and Belgium at a considerably earlier period, and gained possession of the country from the Neolithic race. These are the so-called Celts. Their advent is marked by the introduction of the use of metals into Britain, and they are associated with the Bronze Age. From the custom they had of interring their dead (whom they chiefly cremated) in barrows of a circular shape, they are often known as the Round Barrow people. They show a marked advance in civilization beyond that of Neolithic times, as they were agriculturists and lived by tilling the soil; they manufactured weapons and ornaments of bronze and richly decorated pottery; their flint implements also were of better make, as evidenced by their beautiful barbed arrow heads. To this period belong many of the curious lake dwellings found all over Great Britain and Ireland, Picts' houses of Scotland and Beehive houses of Ireland.

Their osteological remains show that the skull was large, with strongly developed superciliary ridges and glabella, the brow well formed and broad, the upper occipital region not projecting, the tuberosity being the most prominent. In general form the brain case is broader and rounder than in the Neolithic race, the cephalic index centering round 81; they were, therefore, a distinctly brachycephalic people. The upper border of the orbit is thick, the malar bones are prominent and large. The jawbones are large, macrognathous, and likewise the teeth, which are often much ground down; the profile of the upper jaw is somewhat prominent, which gives a prognathous look to the skull; the chin is well formed. The face, as a whole, is of an angular, lozenge form. The ridges for muscular attachments, both on the cranium and face, are well developed, and the expression is very rugged and savage like. Thurnam estimated from the skulls the average age of the persons interred in the Round Barrows to be fifty-five years, while that of the Long Barrows was ten years less.

The stature of the Round Barrow race averages 1·747 meters (5 ft. 9 in.), which is more than the mean stature of the population of the British Isles at the present day. The limb bones are large, with strongly developed ridges and depressions for muscular attachments.

This race is everywhere to be found over Great Britain and Ireland, and, although conquered by the Romans and subsequent invaders, forms a very important element in the population to the present day.

[The extensive colonization of North America by the British renders this paper especially interesting to American readers.—Ed. Supplement.]

THE DIFFUSION OF LIGHT FROM DULL SURFACES.

The London Journal remarks that Christian Wiener has contributed to Wiedemann's Annalen the results of an investigation of the phenomena of the reflection—or, as he prefers to call it, the diffusion—of light from dull surfaces. This inquiry was suggested to Herr Wiener by the problem which presented itself to him in connection with the teaching of descriptive geometry, of representing bodies with their appropriate degrees of brightness. The author begins by stating the accepted law, that the intensity of illumination of an element of an illuminated surface is proportional to the intensity of the source of light divided by the square of the distance from the element, multiplied by the cosine of the angle of incidence. The brightness of the illuminated element, as it appears to the eye of an observer, is proportional to the intensity of illumination thus arrived at and to its own reflective capacity.

According to Lambert's law, this brightness is the same for all angles from which the surface may be viewed. That this law is not always true, was known to Bouguer, who found (in a manner corroborated by Herr Wiener) that when the directions of incidence and of vision are nearly parallel, the brightness is not proportional to the cosine of the angle of incidence, but that with increase of this angle it decreases more rapidly than the cosine. In shaded drawings, Lambert's law is employed almost exclusively, and with good effect. The author refers to the investigations of Herr Lommel, as starting with Fourier from the supposition that the diffusion of light by a body does not proceed from the surface, but from volume elements of the mass of the body, as the coloring of the diffused light demands.

For opaque glowing bodies, Lommel thus arrives at the law of the cosine. He also finds that the length of the path described in the interior of a body by a ray of light before its complete absorption depends wholly upon the absorptive power, not upon the angle of emergence; so that the vertical depth of this diffusing layer, and consequently the amount of the diffused light, must be proportional to the cosine of this angle. This result was confirmed by Herr Moller by observation of glowing metal plates. In his later paper, Herr Lommel arrives at a formula for the intensity of the reflected light, which depends only upon the angles of incidence and emergence.

These results are based upon the tacit assumption that the surface dealt with is matt, or rough. And for such surfaces they are perfectly confirmed by Angstrom's observations on the heat radiation of plane surfaces.

The explanation of the diffusion of light by dull surfaces has been based upon two assumptions. The first is that the disturbance penetrates the surface to a certain depth, and that this layer radiates the disturbance in all directions. This view is supported by the color shown by the dull surfaces and by the fact, ascertained by many experiments, that the diffusion increases, within certain limits, with the thickness of a specially prepared dull layer. Bouguer employed a different hypothesis upon which to base his theory of the diffusion of light. He supposed the rough surface to be composed of a large number of small plane reflecting surface elements lying in all directions, like a tumbled mosaic.

He further supposed the total area of these surfaces in a given direction to be greatest in that of the general surface, decreasing as the angle to it increases; thus producing a preponderating reflection in the sense of the effect of the general surface. Herr Wiener holds that in the case of dull surfaces we have to deal both with penetration of the rays and diffusive reflection from small surface elements; but these conditions vary so with different degrees of roughness and different forms of the prominences offered by rough surfaced bodies, that observation alone will determine the facts for every case.

Herr Wiener began with observations upon the diffusion of light in the case of cast white gypsum, of which two equal plates 25 centimeters square were procured and illuminated in a dark room by a single standard stearine candle of six to the pound. As the unit of brightness, he adopted that shown by such a plate when illuminated perpendicularly by a candle, at one meter distance, seen perpendicularly or very nearly so. The distance of the observer's eye from the plate has no influence upon the brightness. The direct vision of the light was prevented by the interposition of a screen. Several observations were made of the effect of varying the distance of the light and the angles of incidence and emergence upon and from the plates. From these the author has drawn conclusions which apply only to cast gypsum, but not to rough surfaces in general.

Concerning the diffusion of light by gypsum, it may be stated: (1) With a constant angle of incidence and an angle of emergence varying between 0° and 60°, the brightness is pretty uniform and usually somewhat smaller than that demanded by Lambert's law. (2) As the latter angle increases from 60° to 90°, the brightness on the whole diminishes, and at the latter limit, or with a glancing visual ray, it is about 0·6 time that at angle zero. (3) On the side opposite to the incident ray—i. e., on the side of reflection—the brightness is greater than at the corresponding points of equal angle of emergence on the same side. (4) The reflection is more pronounced and evident the larger the angle of incidence. It is therefore noticed that reflection is always greatest with an angle of emergence slightly larger than the angle of incidence. These considerations are not without their bearing upon the construction and use of photometrical instruments.

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TABLE OF CONTENTS.